

Assessment

*Environmental
safety of main
pipelines in Belarus*

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Introduction

Belarus is one of the most important transit countries for gas and oil as it offers the shortest route between the Russian gas and oil fields and the main Western European markets. Most of the country's pipeline system was built in the mid-to-late 1960s and now faces widespread technical renovation. The environmental safety of pipelines crossing Belarus has been an issue for the country's environmental authorities, the civil society and the neighbouring states. Since all major rivers in Belarus are transboundary, any significant accident on a pipeline automatically bears the risk of cross-border pollution, which Belarus is bound to limit as a party to UNECE Convention on the Prevention of Transboundary Risks from Industrial Accidents (the TEIA convention). The responsibilities regarding the environmental safety of pipelines in Belarus are scattered among many institutions including Belarusian environmental and emergency authorities as well as private pipeline operators. In order to identify the actual degree of damage, a systematic assessment of the associated environmental risks is required so that priorities for civil and environmental protection, including the transboundary dimension, can be formulated accordingly.

In 2008, the UNECE Joint Expert Group developed "Safety Guidelines and Good Practices for Pipelines" under the TEIA Convention and the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention). The Guidelines aim to assist in preventing incidents on pipelines and to mitigate the consequences of accidents for human health and the environment. The Guidelines are subdivided into recommendations for the UNECE member countries, the relevant authorities and the operators, and they are split into technical and organizational aspects with reference to pipelines.

Within the framework of Environmental and Security Initiative (ENVSEC) the international project, "Environmental Safety of Oil and Gas Pipelines in Belarus", has been implemented by Zoï Environment Network on behalf of the United Nations Environmental Program (UNEP) and in cooperation with the United Nations Development Program (UNDP). The project applied the UNECE Guidelines on pipeline safety to the corresponding documents in Belarus to assess their compliance with the UNECE guidance document. The assessment was widely discussed

with experts of Belarusian governmental organizations, operators and international organizations during a workshop on 17-18 September 2015 in Minsk, Belarus. The information presented in this report has been taken from open sources.

The experts' analysis of the Guidelines resulted in the drafting of four recommendations that were reviewed by the participants of a workshop on environmental safety of gas and oil pipelines in Belarus. The workshop participants discussed these recommendations, introduced a number of proposals and amendments and adopted a final version that became the main result of the workshop.

Recommendation 1. "We recommend updating technical regulatory legal acts (technical regulations) of Belarus in pipeline transport in line with the legal and regulatory framework that is being created in the Customs Union and in view of best practices of the EU countries."

Being interdependent and having a common content, Recommendation 1 and Recommendation 2 are considered together.

Recommendation 2. "We recommend stepping up the work of the Belarusian National Technical Committee for Standardization "Main pipeline transport of oil, gas and petroleum products" (TK 17)."

The workshop jointly discussed Recommendations 1 and 2 and developed the following additions:

- a) To initiate setting up a single competent body authorized to approve technical regulations in the field of main pipeline transport, whose absence is one of the reasons for the slow development and approval of new technical legal and regulatory acts
- b) To improve the work of Technical Committee (TK17) in all areas which requires creating a favourable environment for its activities' implementation
- c) To start drafting a national system of technical regulatory and legal acts for main pipeline transport in Belarus
- d) To make a list of technical regulations that need to be developed, updated or brought in line with the regulatory framework of the Customs Union

- e) To implement a daily practice of information exchange among operators regarding their current technical regulations, and to create a unified database containing the names of technical legal and regulatory acts of the national pipeline transport operators
- f) To update SNIP 02-05-06-85 and SNIP III 42-80 complying with current approaches, technologies and requirements for technical legal and regulatory acts.

Recommendation 3. "We recommend enhancing the coordination of planning and actions in the event of an emergency on main pipelines through development and implementation of relevant technical regulations."

Following discussions in the groups, the workshop participants developed the following additions with regard to Recommendation 3:

- a) It is necessary to draft a single regulatory act containing a sample plan of elimination of emergencies for main pipeline transport facilities for all operators
- b) Technical regulations require a full and detailed description of public information issues concerning the presence, state, potential threats and emergencies at hazardous production facilities

Recommendation 4. "We recommend upgrading methodological approaches to risk and hazard assessment in emergency on pipeline transport facilities."

Following the discussions of Recommendation 4, the following additions were adopted:

- a) It is necessary to develop a geographic information system (GIS), which takes into account internal factors that determine conditions of a pipeline (design solutions, current technical state, type of maintenance, etc.) and external factors that determine the conditions of escalation or de-escalation of accidents (landscape features, geo-seismic impact, vegetation – including rare species of plants, hydrological situation, and others)
- b) It is necessary to draft a technical regulation, which shall contain methodology of hazards analysis and risk assessment with regard to a potential accident at a main pipeline linear part

Chapter I.

Comparative analysis of the Guidelines and Good Practices to ensure pipeline operational reliability with the regulatory framework of the main pipeline transport of the Republic of Belarus

1.1. Review of the information in the Guidelines

The Guidelines consist of "Introduction" and three main sections: "Principles of Pipeline Operational Reliability", "Recommendations", and "Annex."

The "Principles of Pipeline Operational Reliability" section contains 11 paragraphs. The content of this section holds general requirements for the government, operators (owners) of a pipeline and the organizational and technical issues of operation of pipelines to achieve the basic level of their operational reliability. These requirements are set forth in general terms and can be specified in the form of regulation of the use of different methods and activities, depending on the level of scientific and technological development and regulatory instruments in each country.

The list of these requirements highlights the leading role of governments in ensuring the application of administrative procedures and the liability of operators for the operational reliability of pipelines, adopting measures to mitigate the consequences of an accident, providing general information for the public and the exchange of information with the responsible authorities, the approach to the assessment pipelines integrity, land-use policy, and others.

The "Recommendations" section consists of "Recommendations for UNECE Member States", "Recommendations for Competent Authorities", and "Recommendations for Pipeline Operators".

The first of these subsections contains six paragraphs, in which the UNECE Member States are given recommendations regarding the adoption of safe transportation strategy, definition of the degree of safety, availability of explicit and understandable legislation, development of land-use planning procedures, appointment of responsible authorities, and others.

The second subsection contains 12 paragraphs of recommendations for the competent authorities, including guidance on approaches to land-use policy, establishment of inspections controlling the activities of operators, development of external contingency plans, execution of works for non-interference by third parties, and others.

The third subsection contains six paragraphs with recommendations that pipeline operators at all stages of the life cycle work to prevent accidents and reduce their impact, based on the provision of the necessary regulatory framework, take into account various aspects of impacts on operational safety, carry out risk evaluations, develop a document with regard to pipeline management system, prepare internal contingency plans, and others.

The "Annex" section includes the technical and organizational aspects of the following sub-categories: "Design and Construction", "Construction and Testing," "Pipeline Management System", "Contingency Planning", "Inspection" and "Assessment of Hazards/ Risk and Land Use Planning".

"Design and Construction" contains 22 paragraphs, including general requirements for engineering design, materials, instrumental control, protection against corrosion, fire and explosions, equipment, laying depth and marking for pipeline location.

The "Construction and Testing" subsection has four paragraphs that focus on the requirement for having skilled professionals during construction and for conducting mandatory tests on a pipeline prior to its commissioning, and others.

The "Pipeline Management System" subsection has nine paragraphs revealing the concept of a pipeline management system and its composition. The pipeline management system should consider such issues as organization and staff, identification and assessment of hazards, operational control, introduction of changes, contingency planning, operation monitoring, audit and review.

The "Contingency Planning" subsection contains five paragraphs, divided into "Internal Contingency Planning" (for operators) and "External Contingency Planning" (for the authorities). This subsection provides information about the necessity for drawing up contingency plans, their purpose and content.

The "Inspection" subsection includes five paragraphs with subparagraphs. The subsection provides information about the need for inspection and maintenance of a pipeline, the duties of operators during inspection, an indicative list of works during pipeline inspection, and others.

The last subsection, called "Assessment of Hazards/ Risk and Land Use Planning", contains three paragraphs with sub-paragraphs, and includes a list of approaches and methods for hazard assessment, hazard assessment methods in land-use planning and information about the possible results of risk assessment, depending on pipeline location.

When comparing the Guidelines with similar documents in the Republic of Belarus, it is advisable to initially consider the concept of main pipeline transport, its composition, and legislation governing relations in the main pipeline transport in the Republic of Belarus. This will allow for more in-depth comparative analysis of the documents within the fundamental concepts of the main pipeline transport.

1.2. Definition and structure of the main pipeline transport in the Republic of Belarus

In accordance with Article 1 of the Law of the Republic of Belarus "On Main Pipeline Transport" [2], the main pipeline transport is a type of transport meant for transporting, via main pipelines, products, prepared in accordance with the requirements of technical regulations in the field of technical rate setting and standardization, from the point of acceptance of products to the point of their delivery, transfer to other pipelines or different type of transport or storage facilities.

STB ISO 9000-2006 [3] classifies products of companies by four categories: services, software, hardware and processed materials.

Whether the product is a service, software, hardware or processed material depends on the dominant element. Therefore, the predominant element in the main pipeline transport is a service.

According to the Tax Code of the Republic of Belarus [4], service is considered an activity, the results of which have no material expressions and are sold and consumed in the course of this activity. Service is the result of, at least, one action, which is necessarily implemented with the interaction between the supplier and the consumer. In the field of the main pipeline transport, the provision of services includes actions taken with respect to a tangible product supplied to the customer.

According to the National Classifier of Economic Activities of the Republic of Belarus (OKRB) 005-2006 [5], main pipeline operations refer to section I "Transport and Communications" of section 60 "Operation of overland transport" of group 603 "Transportation by pipeline" of Class 6030 "Transportation by pipeline" of subclass 60300.

This subclass includes:

- Transportation of gases, liquids, liquid solutions and other materials by pipeline;

- Transportation of gases, liquids, liquid solutions and other materials by pipeline
- Services of pump stations and maintenance of pipelines
- The structure of the facilities of the main pipeline, in accordance with Article 4 of the Law of the Republic of Belarus "On the Main Pipeline Transport" [2], includes connected in a single technological process, centrally maintained and managed:
 - Underground, underwater, ground and above-ground pipelines (hereinafter – pipelines) with a set of linear structures
 - Elbows and looping (pipeline sections, laid in parallel to previously built pipelines and technologically interconnected with the latter) of main pipelines
 - Units of electrochemical corrosion protection of pipelines, lines and structures of technological communication, means of remote control and automation of pipelines
 - Underground gas storage facilities
 - Oil pumping stations, storage facilities of oil and oil products
 - Earth storage and other facilities for emergency release of oil, oil products, condensate and liquefied hydrocarbons
 - Power lines and other facilities of power supply for pipelines and other facilities for transportation of oil, gas and oil products
 - Technical means of fire protection and other protective constructions of pipelines
 - Pumping and step-down stations, tank farms, water treatment plants
 - Compressor stations
 - Gas distribution and gas metreing stations
 - Locking devices
 - Oil cargo piers, industrial warehouses
 - Control and emergency repair stations
 - Buildings and facilities of maintenance services
 - Vehicles and their storage area
 - Overhead passages and level crossings over pipelines, access roads to them, permanent roads, helipads along pipeline route
 - Other facilities of main pipeline

1.3. Comparison of the Guidelines and Good Practices to ensure pipeline operational reliability with the regulatory framework in the main pipeline transport

Legislation regulating social relations, including those in the main pipeline transport, provides for various types of regulatory legal acts. In accordance with Article 2 of the Law of the Republic of Belarus as of 10.01.2000 No. 361-3 "On Regulatory Legal Acts" [6], the list includes 18 types of regulatory legal acts: the Constitution of the Republic of Belarus; the Decision of the Referendum; the Framework Law; the Code of the Republic of Belarus; the Law of the Republic of Belarus; the Decree by the President of the Republic of Belarus, and others.

Table 1.1. Comparisons of the provisions of the Guidelines and the provisions of the Law of the Republic of Belarus “On Main Pipeline Transport”

Guidelines and Good Practices to ensure pipeline operational reliability	The Law of the Republic of Belarus “On Main Pipeline Transport”
Principles aim to ensure pipeline operational reliability	Provisions of the Law
1. Governments should play a leading role in establishment and support of the functioning of administrative structures in order to promote the development of safe and environmentally sound transportation infrastructure, including pipelines.	Article 6. Key principles of the operation of main pipeline transport Article 8. Main powers of local Councils of deputies, local executive and regulatory institutions in main pipeline transport Article 10. State regulation in main pipeline transport Article 11. State management in main pipeline transport Article 15. State supervision and control in main pipeline transport
2. Pipeline operator and/or its owner have the primary responsibility for the entire life cycle of its systems for ensuring operational reliability and for taking measures to prevent accidents and mitigate their consequences for human health and the environment. In addition, in case of accidents, there should be all possible measures in place to mitigate their consequences.	Article 17. Ensuring safety for main pipeline operation Article 24. Management of main pipelines or main pipeline system Article 30. Protection of main pipelines Article 31. Organization of works in case of incidents, accidents and emergencies on main pipelines Article 32. Financial support for main pipeline safety Article 36. Compensation for harm inflicted at the stage of construction, reconstruction, operation, conservation and phase-out of main pipelines
3. The construction and operation of pipelines to transport hazardous substances must be such as to ensure prevention of uncontrolled releases of substances into the environment.	Article 13. Technical regulation, standardization and conformity assessment with regard to the requirements of technical regulations in technical rate setting and standardization Article 16. Ensuring safety for main pipeline construction
4. Any leakage from any part of a machine or pipeline containing hazardous substances must be detected properly, quickly and reliably, especially in environmentally sensitive or densely populated areas.	Article 17. Ensuring safety for main pipeline operation
5. A pipeline operator must put in place a management system to strengthen and maintain pipeline integrity. Pipeline integrity should be ensured by appropriate design, construction, maintenance and repair, inspection and monitoring, as well as with the help of a reliable control system.	Article 17. Ensuring safety for main pipeline operation Article 24. Management of main pipelines or main pipeline system
6. Assessing pipeline integrity and potential impact on human health and the environment should be based on a deterministic and/or a probabilistic approach.	Absent
7. In the event of an accident, there should be appropriate actions. Contingency plans should be drafted by pipeline operators (internal contingency plans) and competent organizations (external contingency plans); these plans are to be tested and updated regularly. They have to include a description of the measures necessary to deter the onset of accidents and mitigate their consequences for human health and the environment.	Article 16. Ensuring safety for main pipeline construction Article 17. Ensuring safety for main pipeline operation Article 24. Management of main pipelines or main pipeline system Article 31. Organization of works in case of incidents, accidents and emergencies on main pipelines
8. One should take into account land-use planning policies in the routing of new pipelines (e.g., to limit the proximity of pipelines to populated areas and river basins, as much as possible), and in taking decisions concerning proposals for further development of civil and housing construction near existing pipelines	Article 16. Ensuring safety for main pipeline construction Article 20. Planning of main pipeline construction
9. Pipeline operators and authorities responsible for pipelines should review and, if necessary, develop and introduce a system aimed to reduce the interference of third parties, which is a major cause of accidents, including their transboundary effects.	Article 6. Key principles of operation in main pipeline transport
10. In the event of an accident on pipelines, persons who might be involved must provide information about pipeline operational reliability, its geographical location, measures to ensure the reliability and behaviour required of them. The public should be provided with information of a general nature.	Article 25. Interaction among organizations in main pipeline operation
11. It is necessary to consider the possibility for regular information exchange among pipeline operators and the responsible authorities, regarding good practice, pipeline operational reliability upgrades and previous accidents, as well as cases characterized by high risk of accidents.	Article 8. Main powers of local Councils of deputies, local executive and regulatory institutions in main pipeline transport Article 31. Organization of works in case of incidents, accidents and emergencies on main pipelines



The main pipeline transport is a linearly extended facility containing large quantities of dangerous substances and passing through areas with a variety of natural landscapes, and therefore representing, in the event of an accident, a large potential environmental hazard. Therefore, the most important regulatory legal acts of the highest hierarchical level, regulating activities to ensure environmental safety of trunk pipeline transportation, as well as other activities, are the Constitution of the Republic of Belarus [7], the Water Code of the Republic of Belarus [8], the Forestry Code of the Republic of Belarus [9] and the Code of the Republic of Belarus on Land [10].

The regulatory legal acts of the lower level of the hierarchy, within which main pipeline transport should exercise its operation, given its potential environmental and social hazards, as well as facilities of other industrial activities, are a number of Laws of the Republic of Belarus [11-15].

Activities of the main pipeline transport are directly governed by the Laws of the Republic of Belarus "On the Main Pipeline Transport" [2] and "On Industrial Safety of Hazardous Production Facilities" [16].

The Law of the Republic of Belarus "On the Main Pipeline Transport" [2] defines the legal, economic and organizational basis for the regulation of relations in the main pipeline transport, and aims to provide efficient, reliable and safe operation of the main gas pipelines, trunk oil pipelines and oil products pipelines. It is the most representative analogue for the Guidelines [1].

This Law contains general rules that are binding for all and, in this regard, it differs from the Guidelines, which contain both requirements and recommendations.

At the same time, there is a feature, common to the two documents, which is availability of general requirements without specific quantitative values of any parameters. This feature is usually characteristic of documents of higher hierarchical status and makes comparison of these documents quite justified.

The Law of the Republic of Belarus "On Main Pipeline Transport" contains 40 articles, forming 10 chapters "General Provisions", "State regulation and management of the main pipeline transport", "Organization and operation of the main pipeline transport", "Ensuring safety of the main pipelines" "Construction, operation, preservation and phase-out of the main pipelines", "Operation of the main pipelines", "Lands of the main pipeline transport", "Responsibility for violation of the law and disputes resolution in the main pipeline transport", "International cooperation in the main pipeline transport" and "Final Provisions".

The Law [2] is an independent legal act, the scope of which covers the territory of the Republic of Belarus.

The Guidelines have been developed as an additional document with a scope extending to countries of the UNECE region in the framework of the Convention on the Transboundary Effects of Industrial Accidents and the Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

In this regard, certain provisions of the Law [2] contain more specific and complete requirements in the legal, economic, technical and organizational spheres, as distinct from the first part (principles and recommendations) of the Guidelines.

The first part of the Guidelines has only technical and organizational requirements, which are generalized due to the differences in administrative procedures, legal frameworks and the level of scientific and technological development in the 56 countries of the UNECE region. "Annex" paragraphs of the Guidelines, on the other hand, contain more detailed information in comparison with the provisions of the Law "On Main Pipeline Transport."

The Law [2] describes aspects of seven life cycle stages, such as planning, design, construction, operation, reconstruction, preservation and phase-out of the main pipeline transport.

The Guidelines consider aspects of only four stages of the life cycle (planning, design, construction and operation), which might be explained by the fact that a preserved pipeline without a high excess pressure of pumped medium and a pipeline under phasing out condition without hazardous substances are less hazardous to the environment.

In addition, it is worth noting that the Law [2], in contrast to the Guidelines, provides definitions of the most important concepts, such as "main pipeline", "ensuring environmental safety", "operator", "pipeline protected zone" and others.

The first 11 provisions of the Guidelines (guidelines to ensure operational reliability) that form the basis of the document and are binding, are largely reflected in the Law [2], as it can be seen from Table 1.1. (The content of the relevant articles of the Law [2] is given in Annex 1.) The Table presents comparisons of the provisions of the Guidelines and the articles of the Law [2], which are identical or similar to them with regard to the content.

As shown in Table 1.1, Principle 6 on the application of a deterministic and/or a probabilistic approach in assessing pipeline integrity is not present in the Law [2].

At the same time, Article 16 of the Law [2] puts forward the requirement to provide industrial, fire and environmental safety of pipelines, including the development of an industrial safety declaration as a document containing an analysis and assessment of hazards/risk, however, there are no recommendations or mandatory requirements of the applicable approach in evaluating pipeline integrity in this article.

Recommendations for the UNECE member countries, operators and competent authorities, contained in the Guidelines, complement or extend the principles of the document for pipeline operational safety, a comparative analysis of which is shown in Table 1.1.

The Law [2] does not contain any recommendations, and includes only binding norms, therefore, it is not reasonable to compare the Recommendations of the Guidelines with the requirements of the Law.

At the same time, this report separately undertakes to review the Recommendations of the Guidelines (or parts of the most significant of them) in comparison with the national regulations of the Republic of Belarus (Chapter 4). Furthermore, the current organization of the activities in the Republic of Belarus will be considered in light of the Recommendations of the Guidelines.

However, it should be noted that some paragraphs of the Recommendations of the Guidelines are of particular interest because the provisions contained therein are not reflected in the Law [2]. For example, paragraph 34 of the Recommendations of the Guidelines provides a detailed list of factors that affect pipeline operational safety, including pipeline design and the load factor, the quality of materials, wall thickness, laying depth, protection against external impacts, corrosion, markings, route selection and operation control. Paragraph 36 of the Recommendations outlines the responsibilities of the operator to prepare a document describing the pipeline management system with the establishment of benchmarks for monitoring that system.

The paragraphs of the "Annex" of the Guidelines contain both general and detailed clarifying requirements.

For example, its subsection "Design and Construction" has a large set of data as compared with Article 20 "Planning of main pipelines" and Article 21 "Designing of main pipelines" of the Law [2].

Article 20 of the Law [2] contains rules saying that planning of the main pipelines should be accompanied by a feasibility study of proposed solutions and an environmental feasibility study for their implementation, including a list of measures to protect the environment, as well as a list of measures to protect the social and economic interests of the population within the areas where construction of main pipelines is under consideration, without specific examples and recommendations for the design.

Article 21 of the Law [2] has a provision stating that project design documentation for construction or reconstruction of the main pipelines and their facilities is developed in accordance with the laws of the Republic of Belarus in the main pipeline transport and approved by public authorities, following the procedures as set forth by the laws of the country. It also omits specific examples and recommendations for the design process.

The subsection called "Design and Construction" within the "Annex" contains the paragraphs that indicate the need to define additional static, dynamic and thermal loads acting on a pipeline with examples: load from topsoil, load from traffic over the pipeline, longitudinal ten-

sion as a result of constrained thermal expansion near the stations and load caused by vibration near pumping and compressor stations.

Such detailed requirements for the design, construction, operation and other life cycle stages of trunk pipelines in Belarus are usually not characteristic of regulatory legal acts, which is the Law itself, but of technical regulatory legal acts which are documents of another hierarchical level. For example, comprehensive information on loads at the stage of the design of main pipelines can be found in a number of technical legal acts of the Republic of Belarus [17–24].

The "Pipeline management system" subsection in the "Annex" of the Guidelines is of some interest. In accordance with this subsection, a pipeline management system includes organizational structure, functions, practices, procedures, and resources but also should include issues of management and organization of the staff, identification and assessment of hazards, in-service inspection, modification, operational monitoring, auditing and others.

A concept similar to the pipeline management system is contained in Article 24 of the Law [2], which states that management of main pipelines includes financial and economic management, control over organizational activities, as well as activities to ensure efficient, reliable and safe operation of main pipelines.

Therefore, in the Guidelines, pipeline management is viewed as a systemic approach with elements within the system, much as it is found in the quality management system in accordance with ISO 9000 [3, 25, 26], the OSH management system in accordance with the provisions of OHSAS 18000 [27], and the environmental management system according to ISO 14000 [28, 29].

In the Republic of Belarus the system of regulatory legal documents covering main pipeline transport has not yet reached a unified concept of "main pipeline management system" ("risk management system", "safety management system", etc.). However, the current concept of "main pipeline management", as for its content, can largely coincide with the term "pipeline management system", with a difference in the terminology and wording. This approach to management, i.e., a pipeline management system, may be introduced at specific national enterprises and be reflected in the standards of an enterprise.

The "Contingency Planning" subsection within the "Annex" of the Guidelines includes a detailed description of the contents of plans in case of internal and external emergencies. The Law [2] on contingency planning has general provisions, whereas the detailed contents of contingency plans are provided in other regulatory legal acts, such as the "Regulations on the development of plans for localization and clean-up of incidents and accidents at hazardous production facilities of the "Belneftekhim" consortium" [30].

The "Assessment of hazard/risk and land-use planning" subsection within the "Annex" of the Guidelines lists approaches and methods of risk assessment. The Law [2] does not elaborate on these issues. Nevertheless, approaches and methods of assessment of hazard/risk are part of a number of technical legal acts of the Republic of Belarus [31–34].

Another regulatory legal act, which plays an important role in ensuring safety of the main pipeline transport, is the Law of the Republic of Belarus "On industrial safety of hazardous production facilities" [16]. In accordance with Article 2 of the Law, the facilities of trunk pipeline transport are classified as hazardous production facilities.

The Law [16] defines the legal, economic and social framework to ensure the safe operation of hazardous production facilities and aims to prevent accidents at hazardous production facilities and ensure the preparedness of organizations that operate hazardous production facilities to localize and eliminate the consequences of accidents.

The core of the Law [16] is Chapter 3, "Fundamentals of Industrial Safety", which includes 18 articles. The chapter provides requirements for industrial safety of hazardous production facilities at various stages of the life cycle in combination with the responsibilities of operators and employees; requirements for readiness to eliminate emergencies; aspects of the investigation into the causes of accidents and the development of industrial safety declarations, which is a document containing a comprehensive assessment of risks of accidents, analysis of measures to prevent accidents, etc. The provisions contained in the articles of the Law [16], in terms of its content and focus, are consistent with and complement many provisions of the Guidelines.

When analyzing the regulatory acts of the Republic of Belarus covering trunk pipelines in the framework of the Guidelines, it is necessary to study closely the Law of the Republic of Belarus "On protection of population and territories from emergency situations of natural and man-made disasters" [14]. According to the Law, one of the forms of an emergency is an industrial accident characterized by violation of the conditions of life of people and considerable damage to property. Depending on the territories covered, the amount of material damage and the number of people affected, emergencies are divided into four categories: on-site, local, regional, national and cross-border.

Article 3 of the Law [14] describes the public system of prevention and clean-up of emergencies. The list of the main tasks of the system includes planning, monitoring, forecasting and clean-up of emergencies, development of legal rules to protect against emergencies, exchange and delivery of information in the field of protection from emergencies, preparation of population for emergencies, etc.

Article 7 of the Law [14] on clean-up of emergencies allocates responsibility by category. Therefore, the clean-up of on-site emergencies should be carried out by companies' efforts and means, and emergency responses to other categories with more severe consequences is provided by the relevant authorities.

Articles 12-15 of the Law [14] specify the powers and duties with regard to the protection of the population and territories from emergencies and Article 16 contains obligations of companies. For example, organizations need to plan and implement measures for the protection of workers and facilities from emergencies to ensure the readiness of manpower and means for clean-up of emergencies, to hold training for workers on how to protect themselves, to create and have standby warning systems, to ensure rescue operations are conducted in accordance with the plans of preventing and eliminating emergencies, and others.

The analysis of the provisions of the articles of the Law [14] shows that, in terms of their content and ideology, they generally agree with many of the provisions of the Guidelines.

The contents of the articles of the Law of the Republic of Belarus "On Environmental Protection" [12] are also consistent with the provisions in the Guidelines. Thus, Article 45 about the requirements for the protection of the environment at different stages of the life cycle in the oil and gas sphere states that location, design, construction, reconstruction, commissioning, operation and phase-out of facilities must be done in accordance with the requirements of the environmental protection regulation. In addition, there should be measures in place with regard to cleaning up production waste, land reclamation, reduction of harmful effects on the environment, and moreover, the construction and operation of facilities should be permitted based on the availability of contaminated land rehabilitation projects and positive conclusions of the state ecological experts.



1.4. Comparison of the Guidelines and Good Practices to ensure pipeline operational reliability with effective technical regulatory legal acts in the main pipeline transport in the Republic of Belarus

The next group of documents that play a crucial role in the functioning and safety of the main pipeline transport comprises technical legal acts, including those in the field of civil engineering and architecture.

These documents usually provide an in-depth focus on a facility or process and have specific requirements using formulas and numerical values of parameters or ranges. There can be one document for one process or operation of main pipelines or one life cycle stage.

This fact must be taken into account when comparing the Guidelines, which contain general requirements without numerical values or formulas, with effective technical regulatory acts in the Republic of Belarus. Technical regulatory legal acts are documents that were originally designed to solve problems at various levels of activities to provide main pipeline safety.

At the same time, detailed requirements or numeric standards of technical regulatory legal acts, effective in the Republic of Belarus, largely duplicate, complement and extend the provisions of the Guidelines.

For a more complete understanding and assessment of the necessity and possibility of using the Guidelines' provisions in the regulatory framework of the main pipeline transport in the Republic of Belarus, it is worth summarizing the most important technical regulatory legal acts which are in force in main pipeline transport in the Republic.

The list of types of technical regulations in the field of architecture and construction consists of 12 items [35]: Technical Regulations of the Republic of Belarus (TR), Technical Codes of Practice (TCP), European standards introduced as technical codes of practice (TCP EN), State standards of the Republic of Belarus (STB), Preliminary Standards of the Republic of Belarus (STB P), European and international standards imposed as state standards of the Republic of Belarus (STB EN, STB ISO), Building Codes of the Republic of Belarus (SNB), Building Regulations and Rules (SNIP), and others.

SNIP 2.05.06-85 Main Pipelines [17] is the most significant within the list. This paper examines the important issues of design and construction, such as the requirements for a pipeline route, the design requirements for a pipeline, placement of valves, underground and aboveground pipeline construction, pipeline calculations for strength, corrosion protection, and materials, and others.

Another document is SNIP III-42-80 Rules of production and acceptance. Trunk pipelines [36]. It contains informa-

tion on the preparatory works, earthworks, welding, pipe transportation, the laying of pipelines, electrochemical protection, cleaning pipeline cavities, testing, and others.

Furthermore, technical regulatory legal acts in architecture and construction in the main pipeline transport can include three other documents [37-39].

The technical regulatory legal acts of the Republic of Belarus, in accordance with Article 1 of the Law "On Regulatory Legal Acts" [6], include 19 types of documents: Technical regulations of the Customs Union; Technical regulations (TR); Technical codes of practice (TCP); State standards (GOST, STB); Technical specifications (TS); Aviation Regulations; Zoo-hygienic, veterinary and sanitary rules and regulations; Sanitary norms, rules and hygienic standards; Regulations and rules of fire safety (NPB, PPB); Rules and regulations to ensure technical, industrial, nuclear and radiation safety; Rules and regulations for safe transportation of hazardous products, and others.

The first four types of acts, namely, technical regulations, technical codes of practice, standards, including national standards and standards of enterprises in accordance with Article 15 of the Law of the Republic of Belarus "On Technical Regulation and Standardization" [11] refer to the documents of technical regulation and standardization. This Law of the Republic of Belarus, adopted in 2004, marked the beginning of the reform of the technical regulation and standardization system.

One of the innovations introduced by the Law [11] was the possibility for the formation of Technical Committees, which are specialized associations formed by competent professionals from various relevant organizations to develop technical regulatory legal acts of standardization.

Another innovation of this Law is four new types of acts in technical regulation and standardization.

For instance, technical regulations, which are the highest in a hierarchical status among technical regulatory legal acts, relate to technical regulation and establish technical requirements regarding safety of products and processes. Technical regulations apply across the whole territory of the Republic of Belarus, i.e., are national and mandatory. In Belarus, the technical regulations for the main pipeline transport have not yet been adopted.

The Technical Code of Practice is a document developed in the standardization process and establishes technical requirements for processes based on the results of practice. The Technical Code may be national or departmental. In main pipeline transport, there is a list of technical codes of practice, the requirements of which are consistent with and complementary to most of the paragraphs of the Guidelines.

The main gas pipelines regulation includes the following important technical codes of practice [40-55].

Standard – is a document developed in the standardization process based on the approval of the majority of stakeholders in technical regulation and standardization, which contains technical requirements for products and processes. The standards are divided into state standards, which apply to all, and standards of enterprises, appropriate for a particular company. After the adoption of the Law of the Republic of Belarus "On Technical Regulation and Standardization" [11], the state standards are not mandatory for business entities, in case of availability of adopted technical regulations in this area. At the same time, the state standards are binding, if they are referenced in the technical regulations. Nevertheless, if an operator complies with the requirements of the state standard, it is assumed that the requirements of technical regulations are automatically met, i.e., there exists presumption of conformity. For this reason, operators are trying to comply with the standards. Because of the large number of national standards for equipment and processes, as well as the fact that the standards may not be binding, it is not worth listing the state regulatory standards in main pipeline transport.

Enterprise standards are traditionally developed by leading experts within an organization for the convenience of work, adjustment of operations, tracking of new technologies and processes, and the implementation of internally developed equipment in existing operations. Each organization applies its requirements to the procedure of standard reference. These standards are owned by companies and used exclusively in-house. Given the large number and restricted access to most of them, it is deemed impossible to review them. There is an example of an enterprise standard [55].

Among other technical regulatory legal acts, relating to the rules of fire safety and industrial safety rules, there are three significant papers [56–58].

Therefore, the comparative analysis of the Guidelines with the regulatory framework in the main pipeline transport shows that the principles, recommendations and requirements contained in the Guidelines are largely reflected and complemented in the regulatory legal acts of the Republic of Belarus. The requirements of technical regulatory legal acts in architecture and construction, as well as general technical regulatory legal acts, often with quantitative characteristics and formulas, also largely complement, specify and extend the provisions in the Guidelines.

Chapter II.

Analysis of data on accidents at main pipeline transport facilities in the Republic of Belarus

1.2. General Description of pipeline transport facilities in the Republic of Belarus

Before analyzing data on accidents at the facilities of the main transport, it is advisable to provide an overview of the facilities of the main pipeline transport in the Republic of Belarus.

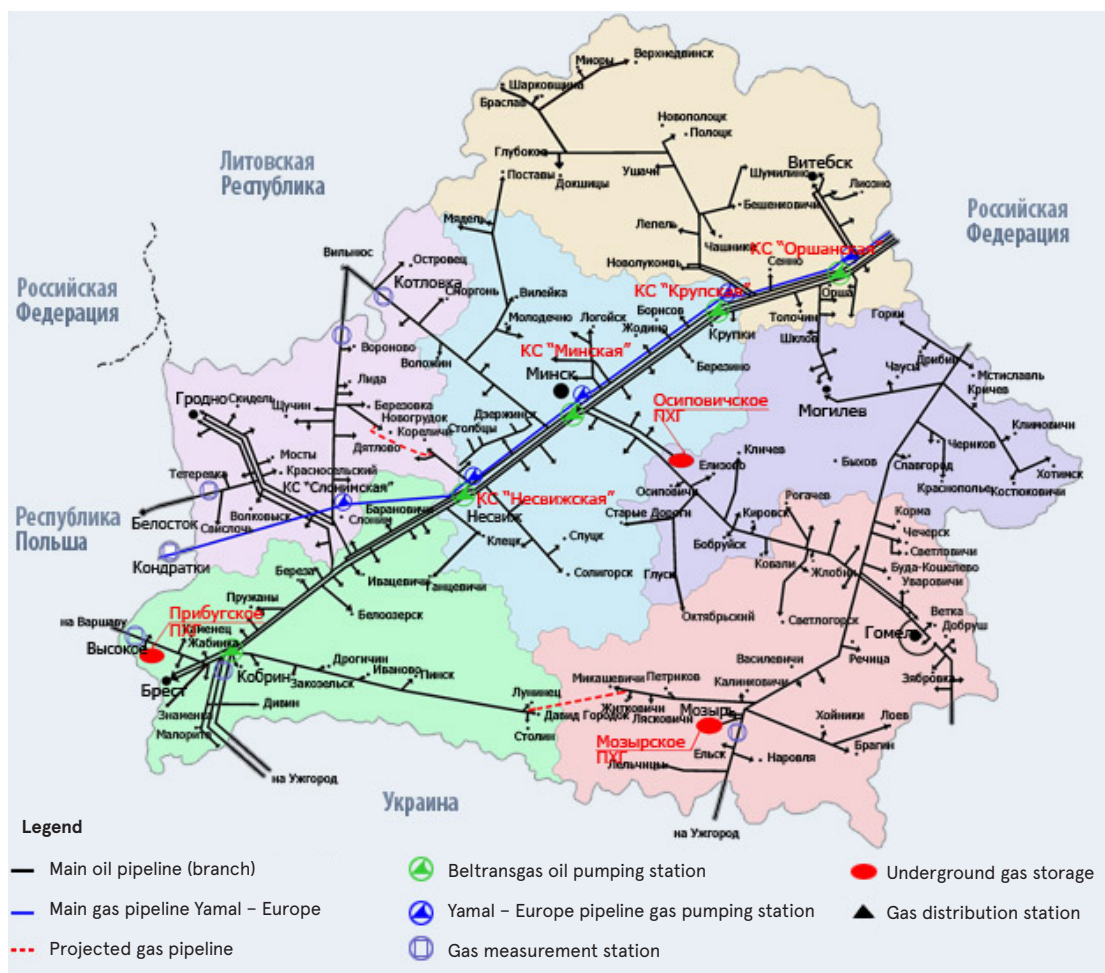
Currently, in the territory of the Republic of Belarus there are four enterprises, which are engaged in transportation of hydrocarbon energy products: OJSC "Gazprom trans-gas Belarus", OJSC "Gomeltransneft Druzhba", OJSC "Polotsktransneft Druzhba", SUE "Zapad-Transnefteprodukt".

The gas transportation system of OJSC "Gazprom transgas Belarus" is technologically connected with similar systems of neighbouring European countries and allows for the transit of Russian natural gas to Ukraine, Poland, Lithuania and the Kaliningrad region of the Russian Federation.

Figure 2.1 shows the main pipeline system of OJSC "Gazprom transgas Belarus" [59].

The system of main gas pipelines operated by OJSC "Gazprom trans-gas Belarus" includes 7 main gas pipelines, 224 gas distribution stations, 3 underground gas storage facilities, and 7 gas metreing stations. The total length of gas pipelines (in single lead calculation) is 7 950 km [59].

Figure 2.1. Main pipelines system of OJSC "Gazprom transgas Belarus"



Russian gas transit through the territory of the Republic of Belarus is provided via the following gas pipelines: triple main gas pipeline "Torzhok – Minsk – Ivatsevichi" with 1 220 mm diameter; twin main gas pipeline "Ivatsevichy – Dolina" with 1 220 mm diameter; main gas pipeline "Kobrin – Brest – Gosgranitza" with 1 020 mm diameter; main gas pipeline "Minsk – Vilnius", 1 220 mm diameter; main gas pipeline "Torzhok – Dolina", 1 420 mm diameter; gas pipeline "Volkovysk – Gosgranitza", 273 mm diameter.

In addition, OJSC "Gazprom transgas Belarus" performs the operator's functions regarding operation of main gas pipeline "Yamal – Europe", with 1 420 mm diameter and 575 km length, owned by OJSC "Gazprom". On main gas pipeline "Yamal – Europe" OJSC "Gazprom transgas Belarus" operates 5 compressor stations with 26 gas turbine compressor units.

As a part of the gas transportation system of OJSC "Gazprom transgas Belarus" there are 8 compressor stations, 5 of which are installed on the linear part and provide gas transportation via main gas pipelines, 3 are installed on underground gas storages and perform gas injection into underground gas storage reservoirs. The compressor stations have 89 gas compressor units.

The Republic of Belarus has a developed system of main oil pipelines. Figure 2.2 shows a diagram of routes of main oil pipelines crossing the territory of the Republic of Belarus.

OJSC "Gomeltransneft Druzhba" [60] provides the supply of Russian and Belarusian oil at OJSC "Mozyr Oil Refinery",

as well as the transit of Russian and Kazakh oil along the following routes: "Inecha-Mozyr-Adamovo" with further transportation to oil refineries in Poland, Germany and the port of Gdansk and "Inecha-Mozyr-Brody" with further transportation to Hungary, Slovakia, the Czech Republic, to the Ukrainian oil refineries and "Yuzhny" seaport. Along the "Rechytza-Mozyr" route oil is delivered from the Rechitskoye oil field for refining at OJSC "Mozyr Oil Refinery".

The oil pipeline route of OJSC "Gomeltransneft Druzhba" crosses the country's largest rivers – the Dnieper and its tributaries of the Pripyat and the Sozh. The "Gomeltransneft Druzhba" company owns 6 oil pumping stations and operates 656 kilometres of oil pipeline, including main oil pipelines with diameters of 1 020, 820, 720, 630 and 530 mm. Overall, the company operates nearly 2 000 kilometres of oil pipelines (in single lead calculation). The tank farm consists of tanks of various capacities.

OJSC "Polotsktransneft Druzhba" [61] owns three oil pumping stations. The company operates trunk pipelines with pipe diameters from 720 to 1 020 mm, namely Unecha-Polotsk Polotsk-Skrudaliena, Polotsk-Mazeikiai and Surgut-Polotsk, passing through the northeastern part of the country, a total length of 1 068 km (Figure 2.2).

The route of pipelines of OJSC "Polotsktransneft Druzhba" crosses the transboundary Zapadnaya River and its tributaries (Ulla, Ushacha, Disna) and the transboundary river of Dnieper and its tributaries (Besed, Sozh, Pronya). There are 39 underwater river crossings, with the total length of 8.85 km.

Figure 2.2. Layout of main oil pipeline routes crossing the Republic of Belarus

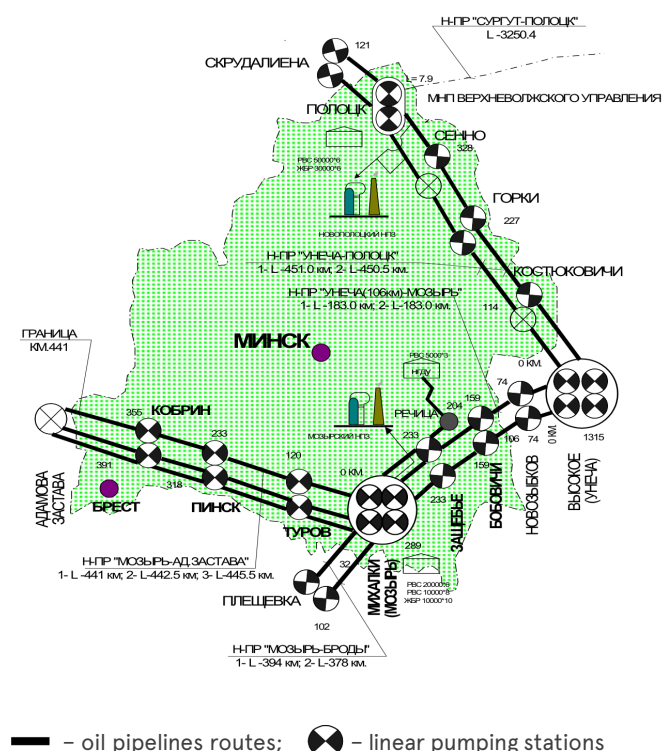


Figure 2.3. Layout of routes of main oil products pipelines, crossing the Republic of Belarus



The state unitary enterprise "Zapad Transnefteprodukt" [62] is a subsidiary of Russian OSJC company "Yugo-Zapad Transnefteprodukt". It carries out transit transportation of light oil products from 12 Russian and 2 Belarusian refineries for export to Ukraine and Latvia via a system of main oil pipelines that crosses 22 regions in 4 oblasts of the Republic of Belarus (Figure 2.3 [63]).

The company operates main oil pipelines, crossing the territory of the Republic, with diameter from 370 to 530 mm in the directions of Unecha-Mozyr, Unecha Polotsk, Disna-Ilukste, with a total length of 900 km. The unitary enterprise "Zapad-Transnefteprodukt" includes 7 separate structural divisions.

Unitary enterprise "Zapad Transnefteprodukt" can export via main oil pipelines passing through Belarus over 10 million tonnes of light oil per year and make trans-shipment of 2 million tonnes of oil per year from pipeline to railway transport by filling rail tankers.

From the above data, one can conclude that, due to its advantageous geographical position, the Republic of Belarus has an extensive network of trunk pipelines with a total length of over 11 000 km.

The operation of the main pipelines of such extent is related to the risk of accidents, which might be accompanied by gas, oil and oil products leakage out of pipelines and environmental pollution.

2.2. Analysis of the risk of accidents at pipeline transport facilities in the Republic of Belarus

According to the Law of the Republic of Belarus "On industrial safety of hazardous production facilities" [16], an accident is considered to be a destruction of structures or technical devices used at hazardous production facilities, uncontrolled explosion or release of hazardous substances.

The results of accidents on main gas pipelines are the consequences characterized by the greatest severity in the social sphere and having the form of large explosions and the possibility of affecting people.

Accidents on the main oil pipelines and oil products pipelines are accompanied by after-effects mainly related to the environment, caused by leakage of large amounts of spilled oil into ecosystems.

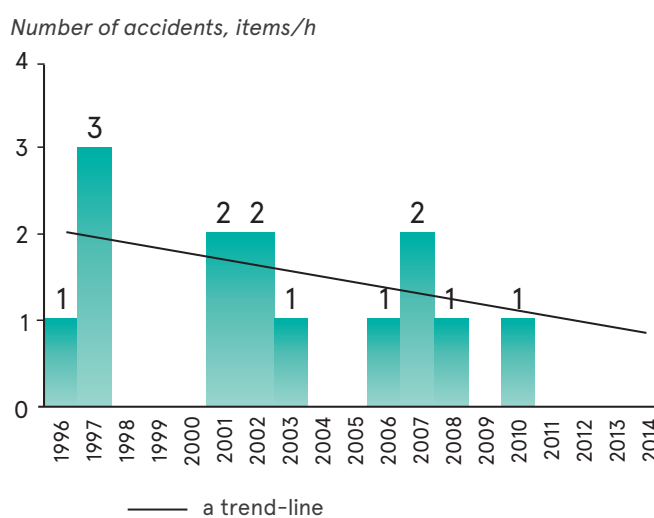
According to the statistics, there were 14 accidents (listed in Table 2.1) on the main pipelines of the Republic of Belarus from 1996 to 2004. Nine of these accidents had oil and oil product spills and contamination of soil or water bodies.

As seen in Table 2.1, in the last five years there has been one accident at oil and gas transportation facilities,

and not a single accident involving their personnel. This downward trend in the number of accidents in recent years is largely due to the high quality and safe work of operators, professional and competent work of specialists with the Department of Supervision of safety in industry, the upgrading of the regulatory framework in main pipeline transport, and the growth of science and technology achievements.

The distribution of the number of accidents by year is in Figure 2.4.

Figure 2.4. Number of accidents on the main pipelines



As indicated in Figure 2.4, the trend line gives the dynamics of change in the number of accidents on main pipelines and shows a decreasing tendency in their numbers.

Most of those accidents did not result in significant after-effects, as shown in a graph of the distribution of property damage due to accidents (Figure 2.5). Still, in the period under review, major accidents accompanied by considerable material damage occurred with a frequency of one accident every 10 years. These include the 1997 accident on gas pipeline "Torzhok-Minsk-Ivatsevichi" and the 2007 accident on oil pipeline "Unecha-Ventspils".

Figure 2.5. Distribution of property damage

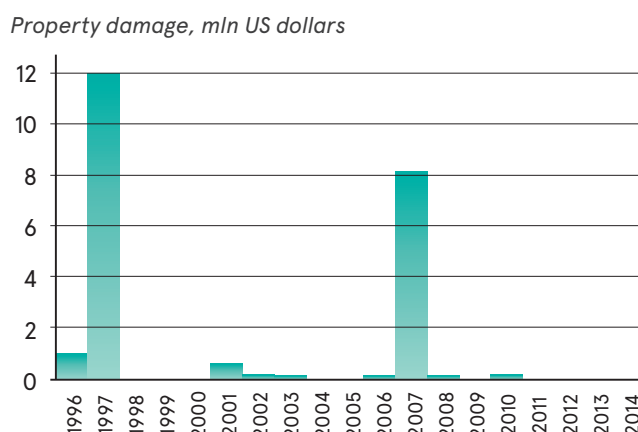
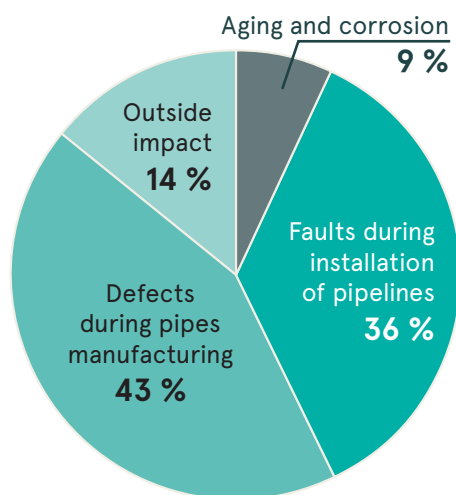


Table 2.1. Data on accidents on the main pipelines from 1996 to 2014

No	Company	Date of accident and date of elimination	Place of accident	Causes of accident → Severity of its consequences
1.	SUE "Zapad-transnefte-product" (Russia)	12.02.1996 – 13.02.1996	Oil product pipeline near v. Zhgun-Buda of Dobrushsky district, Gomel oblast	Faulty tube metal → spill of diesel over 0.7 ha area
2.	OJSC "Beltransgaz"	28.04.1997 – 28.04.1997	Dust chamber of a compressor station near v. Staroselye of Krypsky district, Minsk oblast	Outside source → gas leakage with fire
3.	OJSC "Beltransgaz"	30.04.1997 – 03.05.1997	Gas pipeline "Torzhok-Minsk-Ivatsevichi", II branch near v. Mogilno of Uzdensky district, Minsk oblast	Outside source → gas leakage into atmosphere with fire
4.	SUE "Zapad-transnefte-product" (Russia)	17.06.1997 – 24.06.1997	Section No. 42 of oil product pipeline near v. Zhgun-Buda of Dobrushsky district, Gomel oblast	Faulty tube metal → spill of diesel over 2.1 ha area
5.	OJSC "Beltransgaz"	23.04.2001 – 25.04.2001	Pipeline "Minsk-Gomel" near v. Staray Rudnya of Zhlobinsky district, Gomel oblast	Mechanical tube damage in the process of construction → gas leakage into atmosphere without fire
6.	SUE "Zapad-transnefte-product" (Russia)	30.10.2001 – 01.11.2001	Oil product pipeline "Disna-Ilukste" near v. Rudaki of Miorsky district, Vitebsk oblast	Fault of welding joint during construction → spill of diesel over 1.5 ha area
7.	OJSC "Beltransgaz"	04.02.2002 – 06.02.2002	Gas pipeline elbow to v. Novopolotsk near v. Kamen of Lepelsky district, Vitebsk oblast	Fault of welding joint during construction → gas leakage into atmosphere with fire
8.	SUE "Gomeltransneft Druzhba"	20.07.2002 – 21.07.2002	Oil pipeline "Mozyr-Brest II», section "Turov-Pinsk" near v. Vysokoye of Stolinsky district, Brest oblast	Loss of mechanical properties of tube metal during operation → oil spill over 8.7 ha area
9.	SUE "Gomeltransneft Druzhba"	30.08.2003 – 01.09.2003	Oil pipeline "Mozyr-Brest I», near v. Glinitsa of Mozyr district, Gomel oblast	Fault of manufacturer's welding joint → oil spill over 1 ha area
10.	OJSC "Beltransgaz"	10.02.2006 – 12.02.2006	Gas pipeline-elbow to gas distribution station near v. Zazeritsa, Chashnitsky district, Vitebsk oblast	Fault of welding joint of ball valve during manufacturing → gas leakage into atmosphere with fire
11.	SUE "Zapad-transnefte-product" (Russia)	23.03.2007 – 24.03.2007	Section No. 41 of oil product pipeline of Beshe nkovich district of Vitebsk oblast	Faulty tube metal → diesel spill over the area and into reclamation canal, in the river of Ulla and Zapadnaya Dvina → transboundary transfer
12.	SUE "Zapad-transnefte-product" (Russia)	05.05.2007 – 06.05.2007	Section No. 41 of oil product pipeline of Beshe nkovich district, Vitebsk oblast	Faulty tube metal → diesel spill over the area and into the reclamation canal
13.	SUE "Zapad-transnefte-product" (Russia)	14.02.2008 – 17.02.2008	Section No. 42 (underwater crossing across the Dnieper river) of Rechitsky district, Gomel oblast	Fault during construction and installation → diesel spill over the area with contamination of inundated reservoir
14.	SUE "Gomeltransneft Druzhba"	20.12.2010 – 21.12.2010	Oil pipeline "Mozyr-Brest II-branch" near v. Grushevka of Kamensky district, Brest oblast	Rupture in the weld zone of the cross junction due to fault in construction and installation works → oil spill on 0.6 hectares with fire

The study and analysis of the causes of accidents at the main pipeline transport facilities makes it possible to give their distribution in percentage. The results of the analysis are shown in Figure 2.6.

Figure 2.6. Causes of accidents on main pipelines



As indicated in the figure, the largest number of accidents on main pipelines was due to manufacturing piping defects – 43 per cent and faulty construction and installation works – 36 per cent. The occurrence of these causes of accidents chronologically refers to a certain stage in the life cycle of a pipeline, i.e., its construction.

Geographical location of the accidents is sufficiently dispersed and has no clear district concentration, which is confirmed by Figure 2.7. The figure presents the main routes of trunk oil pipelines, oil product pipelines and gas pipelines. The numeric characters indicate locations of accidents, and the number of a location coincides with the serial number of an accident in Table 2.1. As shown in Figure 2.7, closely spaced locations of accidents are attributed to subpar quality of construction of individual sections of trunk pipelines. The repair of these sections has enhanced the reliability of these sites. Therefore, the probability of an accident specifically in those places in the future is minimal.

As shown in Figure 2.7, some accidents took place close to water bodies. For example, 3 out of 14 accidents were related to the oil and oil products' spill and pollution of water bodies, and 6 accidents led to soil pollution.

Figure 2.7. Locations of accidents on the main pipelines since 1996

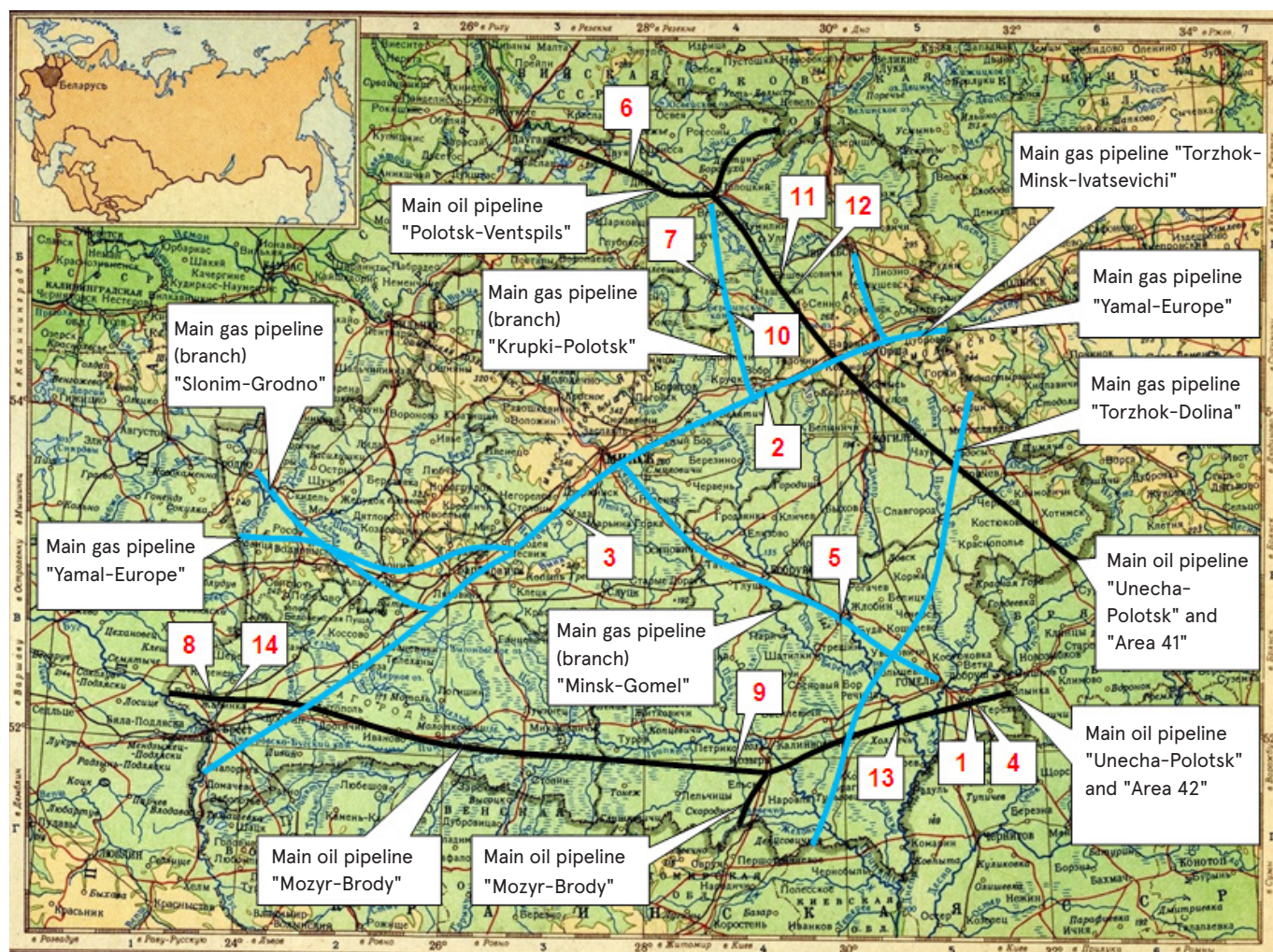


Figure 2.8. Actions aimed at clean-up of after-effects of accidental oil in the Ulla River



One of the accidents was accompanied by a transboundary transfer of oil products. This accident occurred March 23, 2007, in the Beshenkovichi district on oil pipeline Unecha-Ventspils (in Table 2.1 it is given under position No. 11), which resulted in 125 cubic metres of diesel fuel spilled on the ground and entering the reclamation canal through which it reached the Ulla River and then the Zapadnaya Dvina River. Moving along the Zapadnaya Dvina River, the diesel spill crossed the border with Latvia on March 26 [64], though only about 3.7 tonnes of diesel fuel eventually reached the Latvian territory.

There were two reasons worth mentioning, which minimized the transboundary transfer of spilled oil during this accident.

The first one is the prompt response and efficiency on the part of rescue and emergency units of the operator, as well as other pipeline operators, who took part in the accident's clean-up, and the services of the Ministry for Emergency Situations. They jointly conducted clean-up of the spill and its collection in the territories and water-courses located in the affected area. (See Figure 2.8.)

The second fact is the existence of the stationary barrier for retaining oil and oil products that was built and efficiently used on the Zapadnaya Dvina River near the Belarusian-Latvian border in the former period (Figure 2.9). The facility was designed and erected based on scientific recommendations of the Department of pipeline transport, water supply and hydraulics with the educational institution of Polotsk State University. This barrier made it possible to minimize the transboundary transfer of oil spill to the territory of Latvia.

Due to the measures taken on March 30, 2007, the level of contamination of the Zapadnaya Dvina on the border with Latvia did not exceed the maximum allowable concentrations [65]. The owner of the oil products pipeline paid Latvia the amount of LVL 318 246 (about US \$666 000). The bulk of this amount was used to cover the costs associated with the work to eliminate pollution of the Daugava [66]. The cause of this accident was the poor quality of materials used in the 1970s for the construction of this section of the oil product pipeline.

Figure 2.9. The stationary barrier to retain oil on the Zapadnaya Dvina River



The analysis of the causes of accidents shows that the accidents occurred due to deviations from the requirements of the national technical regulations. At the same time, the conditions surrounding these accidents can be regarded as instances of non-compliance with certain paragraphs of the Guidelines.

2.3. Analysis of the accidents against the provisions of the Guidelines

The study of accidents on the main pipelines in the Republic of Belarus allowed for analyzing their causes and consequences in terms of compliance with the provisions of the Guidelines. The results of this analysis are given in Table 2.2 (columns 4 and 5).

As an example, we present a more detailed analysis of the causes and consequences of a specific accident that involved a transboundary oil transfer. This accident occurred March 23, 2007, in Beshenkovichsk district on the oil product pipeline Unecha–Ventspils (Table 2.2, position No. 11).

Causes and consequences of the accident can be attributed to non-compliance with the requirements of paragraphs 2, 3, 8, 18, 20 and 32, namely:

- The operator of the pipeline did not provide operational reliability – violation of principle No. 2
- The pipeline design did not prevent uncontrolled leakage of substances into the environment – violation of principle No. 3
- The pipeline's location in the ground made it possible for the leakage of oil product migrate to the Ulla and the Zapadnaya Dvina – violation of principle No. 8

Table 2.2 Accidents and compliance with the principles of the Guidelines

No	Company and date of accident	Cause of accident → Scope of consequences of accident	Non-compliance with the paragraphs of the Guidelines	
			Principles	Recommendations
1.	SUE "Zapad-Transneftprodukt" (Russia), 12.02.1996	Faulty tube metal → diesel fuel spill on 0.7 ha area	2, 3, 8	32
2.	OJSC "Beltransgas", 28.04.1997	Outside impact → gas leakage with fire	2, 3, 9	29, 32
3.	OJSC "Beltransgas", 30.04.1997	Outside impact → gas leakage into the air with fire	2, 3, 8, 9	29, 32
4.	SUE "Zapad-Transneftprodukt" (Russia), 17.06.1997	Faulty tube metal → diesel fuel spill on 2.1 ha area	2, 3, 8	32
5.	OJSC "Beltransgas", 23.04.2001	Mechanic tube damage during construction → gas leakage into the air with fire	2, 3	32
6.	SUE "Zapad-Transneftprodukt" (Russia), 30.10.2001	Faulty weld joint during construction → diesel fuel spill on 1.5 ha area	2, 3	32
7.	OJSC "Beltransgas", 04.02.2002	Faulty weld joint during construction → gas leakage into the air with fire	2, 3	32
8.	SUE "Gomeltransneft Druzhba", 20.07.2002	Loss of mechanic properties of tube metal during operation → oil spill on 8.7 ha area	2, 3, 8	32, 34
9.	SUE "Gomeltransneft Druzhba", 30.08.2003	Faulty manufacture's weld joint → oil spill on 1.0 ha area	2, 3	32
10.	OJSC "Beltransgas", 10.02.2006	Faulty weld joint of a ball valve during manufacturing → gas leakage into the air with fire	2, 3	32, 34
11.	SUE "Zapad-Transneftprodukt" (Russia), 23.03.2007	Faulty tube metal → diesel fuel spill on the area and contamination of the reclamation canal, the Ulla river and the Zapadnaya Dvina river → transboundary transfer	2, 3, 8,	18, 20, 32
12.	SUE "Zapad-Transneftprodukt" (Russia), (Россия), 05.05.2007	Faulty tube metal → diesel fuel spill on the territory and contamination of the reclamation canal	2, 3,	32
13.	SUE "Zapad-Transneftprodukt" (Russia), 14.02.2008	Faulty construction and installation works → diesel fuel spill on the territory and contamination of the inundable reservoir	2, 3, 8	32
14.	SUE "Gomeltransneft Druzhba", 20.12.2010	Rupture in the weld zone of the cross junction due to fault in construction and installation works → oil spill on 0.6 hectares with fire	2, 3, 8,	32

- The lack of proper monitoring and control resulted in the contamination of not only the Ulla River, but also the Zapadnaya Dvina – violation of recommendation No. 18
- Despite the measures taken to contain the spill, some amount of oil product was transferred over the border revealing insufficient measures for creating safe zones and/or other appropriate strategies – violation of recommendation No. 20
- Technical solutions adopted for the design, construction, operation, maintenance and monitoring of the pipeline did not prevent the accident – violation of recommendation No. 32

In general, the analysis of all accidents revealed that the occurrence of the accidents was due to non-compliance with principles No. 2 and No. 3 and recommendation No. 32 of the Guidelines. Principle No. 2 is the operator's responsibility to ensure the operational reliability of pipelines. Principle No. 3 contains requirements for design reliability and safe operation of pipelines. Recommendation to the operators No. 32 concerns ensuring trouble-free performance of a pipeline during all stages of its life cycle. It should be noted that these principles and recommendations are general requirements, and every single accident in any country will fall under these two principles and the recommendation.

The accidents under consideration can mainly be explained by the fact that when the pipelines were con-

structed in the 1960s the risk of an accident was considered not from the standpoint of environmental impact, but in terms of disrupting the transfer of the product. The current priority concern has significantly changed. Construction of new pipeline systems is dominated by the use of technologies that can ensure a high level of environmental safety.

In this regard, it is necessary to point out that the majority of oil pipeline routes (Figure 2.10) violates principle No. 8 of the Guidelines on land-use planning, as the oil pipelines are laid in floodplains. In the event of an accident on these oil pipelines, the probability of contaminating waterways is quite high.

The danger of a spill increases many times due to the fact that oil can be transported along the tributaries into large rivers and further on, over considerable distances, can have a negative environmental impact on vast areas. Even more important is that contamination of large rivers with oil and oil products during major accidents can be accompanied by a transboundary transfer of hazardous substances.

The trunk oil and oil product pipelines in the Republic of Belarus cross through territory with a dense river network, and along major rivers of cross-border traffic, such as the Zapadnaya Dvina, the Dnieper, the Pripyat, and the Zapadny Bug [67].

Figure 2.10. Location of routes of main oil and oil product pipelines in Belarus

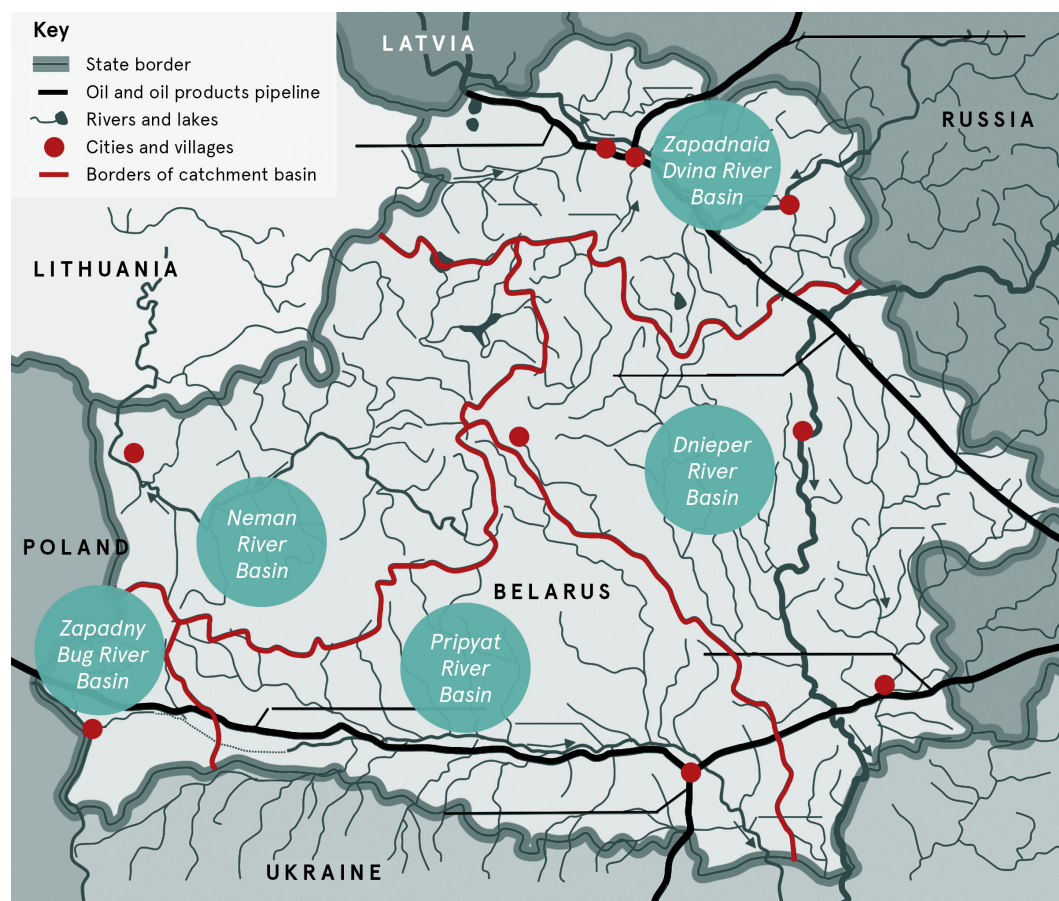


Table 2.3 Number of underwater crossings on the routes of oil and oil product pipelines

Routes	Number of large crossings	Total number of underwater crossing branches	Including rivers	Streams crossed
Oil pipelines	18	64	Zap. Dvina, Disna, Ulla, Dnieper, Sozh, Pripyat, Goryn', Stviga, Styr', Ubort', Lake Glinitskoye	261
Oil product pipelines	8	16	Pripyat, Dnieper, Sozh, Besyad', Disna	72

The north-western part of the territory is located in the catch basin of the Baltic Sea, and its south-eastern part is in the Black Sea basin, therefore, transboundary transfer can lead to a risk of pollution of these waters.

Approximately 45 per cent of the length of the oil and oil product pipeline routes is along the channels of large rivers (the Zapadnaya Dvina, the Pripyat) at a slight distance from them. This circumstance creates conditions for oil spills to come directly into these rivers during accidents and poses a potential threat to the Baltic and Black Seas.

The immediate and most serious environmental hazards are linear sections of trunk oil pipelines laid under the riverbeds – underwater crossings. Danger from underwater crossings is huge, as in case of an accident, a significantly greater quantity of oil than from underground or aboveground pipelines can instantaneously get into the river flow and spread contamination faster along watercourses.

On the territory of the Republic of Belarus, trunk oil pipelines cross 15 major rivers, including the Pripyat, the Sozh, the Dnieper, and the Zapadnaya Dvina. Overall, there are 18 underwater crossings of the main oil pipelines and 8 underwater crossings of the main oil product pipelines in the country (Table 2.3).

During the construction of pipelines in the 1960s, the main doctrine was to ensure security of energy supplies by duplicating the most dangerous structural elements. This approach explains why additional pipes (which are called redundant branches) were laid for underwater crossings. In fact, the situation is that there are additional pipes filled with oil or oil products under rivers. The total number of the branches of underwater crossings in Belarus is 80 units.

This current situation, characterized by great potential environmental hazard to the pipeline systems, taking into account the accidents that have occurred, requires the development of measures to ensure safe operation of these facilities. In Belarus, those preventive measures are activities aimed at supervision of technical conditions of the main pipeline transport.

2.4. Approaches used for risk assessment in the main pipeline transport in the Republic of Belarus

Given the fact that the main pipeline is potentially dangerous for the environment, it is necessary to analyse its safety in order to reveal possible causes of accidents, prioritize their danger and develop a list of preventive measures.

Currently, the safety assessment widely uses a risk-based approach, taking into account risk analysis and assessment, which, however, different scholars treat differently.

The paper [90] distinguishes between qualitative and quantitative methods of risk assessment. The authors of the paper [91] subdivide risk assessment methods into quantitative, qualitative, vague and logic-graphics. The technical regulatory legal act [92] divides methods into inductive and deductive. The paper [93] points out that risk assessment methods are divided into phenomenological, deterministic and probabilistic. As described in the document [94], methods can be divided into ascending and descending. In accordance with the last source [95], risk assessment methods include qualitative, semi-quantitative and quantitative. Therefore, the risk assessment method, based on different classifications, can be quantitative, inductive, deterministic, and ascending, all at the same time.

The Technical Committee (TK 262) on risk management, established under the International Organization for Standardization as a working group, has developed an international standard for risk assessment methods [95], supplementing the ISO 31000 series of standards in risk management. This standard provides a brief description of over 20 methods used in assessing risks of different nature and origin. A review of risk assessment methods makes it possible to prioritize these methods on the criteria of resource intensity, labour intensity, possibility for identification and quantitative risk assessment, and recommended conditions of application, as given in Table 2.5.

In Belarus, risk assessment for the main pipeline transport facilities is described in the document called the Declaration of Industrial Safety, which must be present at each pipeline operator's production facility.

Table 2.5 Risk assessment methods

No	Methods	Risk identification	Quantitative risk assessment	Resource intensity level	Labour intensity level
1	Failure mode and effect analysis (FMEA)	+	+	medium	medium
2	Business influence analysis (BIA)	+	–	medium	medium
3	Fault tree analysis (FTA)	+	+	high	medium
4	Event tree analysis (ETA)	+	–	medium	medium
5	Layers of protection analysis (LOPA)	+	–	medium	medium
6	Hazard and operation analysis (HAZOP)	+	+	medium	high
7	Sneak circuit analysis (SCA)	+	–	medium	medium
8	Hazard analysis and critical control points (HACCP)	+	–	medium	medium
9	Root cause analysis (RCA)	–	–	medium	medium
10	Failure reporting and corrective action system (FRACAS)	–	–	medium	medium
11	Cause-Consequence analysis (CCA)	+	+	high	high
12	Cost-Benefit analysis (CBA)	+	–	low	medium
13	Human reliability analysis (HRA)	+	+	medium	medium
14	Bayes analysis (BA)	–	+	high	high
15	Delphi	+	–	medium	medium
16	Decision tree (DT)	–	–	medium	medium
17	Fishbone graph	+	–	low	medium
18	Risk indexes)	+	–	medium	medium
19	Markov analysis	+	+	high	high
20	Consequence/probability matrix	+	+	medium	medium
21	Multi-criteria decision analysis (MCDA)	+	–	high	high
22	Brainstorm	+	–	low	low
23	Монте Карло (Monte Carlo)	–	+	high	high
24	Environment Impact Assessment (EIA)	+	+	high	high
25	Paired comparison	–	+	medium	medium
26	Preliminary hazard analysis (PHA)	+	–	low	medium
27	Check-lists	+	–	low	low
28	Structured or semi-structured interview	+	–	low	low
29	Petri net	–	+	high	high

Footnotes:

+ – possible to apply; – – impossible to apply

The Declaration of Industrial Safety highlights such aspects of enterprises, as the degree of hazard of enterprises for the environment and surrounding industrial and civil facilities, the probability of occurrence of various accidents and the potential damage from those accidents. An industrial facility's readiness to localize and mitigate such accidents is studied separately.

Risk assessment makes it possible to have the opportunity to influence the scope of the potential hazard posed by the enterprises under analysis. For this reason, pipeline transport operators are especially interested in the use of risk assessment methods that would determine how each implemented activity modifies the total risk amount. This interest is due to the fact that it is easy to calculate the monetary value of each specific action to

reduce the risk. In this regard, the greatest interest is the methods of quantitative risk assessment.

In the Republic of Belarus, such methodology is presented by the regulations GOST 12.1.004 [96] and TKP 474 [97]. These documents calculate the value of individual and collective risk to personnel of on-site facilities (such as pumping stations, tank farms, oil depots and other facilities) and the population residing nearby. An example of this calculation is given in Appendix 1. The focus of these methods might be assumed to be directed to ensuring social, rather than environmental, security.

Linear sections of main pipelines have specific features, consisting in a fundamentally different interaction of an industrial facility with the environment. The linear



section goes through a variety of areas with different geological, climatic, hydrological and other conditions. On the linear section of a main pipeline, unlike on-site structures, emergencies are difficult to detect because of the large extent of the line, its underground location and lack of staff. Detection of an emergency on a pipeline linear section, unlike its on-site structures, requires significantly more time for the arrival of emergency teams, equipment delivery and mitigation of effects. The main impact on the environment in an accident on a linear section affects the environment, rather than the social sphere. In this case, the applications of the methods as described in GOST 12.1.004 [96] and TKP 474 [97] are very restricted and do not allow for a full risk assessment for the facility in question.

In this connection, risk assessment for linear sections of trunk pipelines is usually done by the combined use of methods [98] and [99]. In this case, one can obtain the value of risk for each metre of the pipeline. An example of risk assessment for a linear facility of a trunk pipeline is given in Annex 2.

In general, the use of risk analysis methods allows pipeline transport operators to analyse a facility technical condition and implement measures aimed at ensuring trouble-free operation and reduction of environmental hazard from its facilities.

One of the main goals to be achieved within the current project is the analysis and assessment of the level of hazard of the main pipelines located on the territory of Belarus. As noted in this section of the report, a vari-

ety of methods have been developed and implemented to analyse and assess a hazard level (Table 2.5). Each of these methods has its inherent features, which determine the scope of its use and labour intensity.

Risk assessment methods for the analysis of the level of hazard of the linear sections of main pipelines, based on the combined application of methods [98] and [99], provide the best insight into various types of hazard (industrial hazard, environmental hazard, social hazard, etc.) that are associated with the operation of these facilities (Annex 2 and 3).

A sufficiently comprehensive and detailed understanding of hazards posed by linear sections of main pipelines, obtained with these methods, is primarily aimed at planning and development by trunk pipeline transport operators of the specific technical-organizational and engineering and technological measures, to minimize hazards of linear sections.

At the same time, these methods are characterized by high labour and resource intensity requiring longer working hours and greater financial resources. Therefore, these methods are used in relation to specific linear sections of main pipelines.

Another feature associated with the use of these methods is that their application calls for compilation of an extensive database containing technical state and operating conditions of a pipeline, with some information being confidential and owned by the operator.

Within the current work, the use of hazard assessment methods for trunk pipelines, based on a risk analysis under the methods presented in [98] and [99], is deemed impossible for a number of reasons. The complexity of these methods in relation to the entire network of main pipelines in Belarus, whose single lead length is about 11 000 km, calls for significant human, financial and time resources.

The results of hazard assessments of main pipelines, which will be obtained in this project, are intended to be used not as inputs for planning and development of organizational-technical and engineering and technological measures, aimed at minimizing the hazard of specific line sections, but for evaluation and analysis of the hazard level of the main pipelines of Belarus as a whole. In this regard, there is no need for specific and detailed information on hazards of main pipelines.

The hazard of main pipelines, as studied in this work, should be reviewed in two ways: in terms of industrial safety, which is primarily characterized by pipeline reliability, which, to a greater extent determines the level of failure-free operation; and in terms of environmental safety, which is mainly characterized by the nature and scale of the environmental impacts that accompany accidents on main pipelines.

To assess the industrial safety level, it is necessary to conduct risk assessment by quantitative methods, requiring a large and diverse database, which cannot be compiled within this task for various reasons, as well as significant labour, financial and time resources (Annex 1, 2), exceeding the resource potential of the project. Therefore, the calculations of probability of accidents on main pipelines in Belarus have not been done.

At the same time, it should be noted that one of the causes of accidents on main pipelines is intrusion of unauthorized persons (both deliberate and unintentional), the probability of which increases in the sections of main pipelines routes near settlements. Naturally, this increases the risk of accidents, and consequently reduces the level of potential industrial safety. Such linear sections of main pipelines are marked on the map.

To evaluate the level of environmental safety of trunk pipelines, one can use both quantitative (risk assessment-based) and qualitative methods. As mentioned above, quantitative methods for assessing environmental safety level have not been used in this paper.

The assessment of environmental safety levels of main pipelines has been carried out by a qualitative method. A feature that was used in a qualitative assessment of the environmental hazard level of specific linear sections of main pipelines and their ranking was the relative position of the main pipeline route and those elements of the environment, which, to a greater degree, can be exposed to the impacts of an accident on the pipeline, leading to adverse after-effects.

As already mentioned, one of the causes of accidents on main pipelines is the intrusion of third parties, the probability of which increases in the sections of pipeline route in the proximity of settlements. Naturally, the rise in accidents through this factor results in enhanced pipeline environmental hazard in these areas.

In this connection, an additional criterion for assessing the environmental hazard level on specific linear sections of pipeline routes has been determined as the relative position of the main pipeline route and settlements, where the probability of such intrusions increases.

During the evaluation and analysis of the environmental safety level of main pipelines, gas and oil pipelines were studied separately.

Accidents on main gas pipelines can create significant adverse effects in the economic and social spheres. By contrast, the environmental effects are small scale and manifest mainly in the form of air pollution with natural gas coming from a damaged gas pipeline and products of combustion in the event of fires during an accident.

In this regard, main gas pipelines, in terms of environmental hazard, are placed in a separate group. The extent of their environmental hazard does not depend on landscape conditions in the territories of pipeline routes, therefore, they form a category of pipelines characterized by a low level of hazard.

The negative environmental impacts of accidents on the main oil pipelines occur when accidents are accompanied by oil spills from a damaged pipeline (accidental oil spill). The spilled oil affects the environment causing adverse environmental impacts.

When ranking the linear sections of oil pipelines, based on the level of environmental hazard, along with the nature of environmental features that might be contaminated with oil spills, we took into account the existing conditions and possibilities within a given linear section of the oil pipeline for prompt emergency and rescue operations aimed at minimizing the environmental impacts of accidental oil spills.

The greatest environmental threat, in terms of scale of impacts, is the pollution of transboundary rivers and specially protected land (reserves, sanctuaries, etc.). Linear sections of oil pipelines, where accidents could lead to direct contamination of the environment, are classified as pipelines with the highest environmental risk.

This category includes linear sections of underwater crossings that cross transboundary rivers within the boundaries of cross dimension of river floodplain in the place of its crossing; oil pipeline linear sections cross the territory of protected land.

During accidents on those sections, all of the spilled oil directly enters a transboundary river (an underwater

crossing) or protected land, resulting in maximum negative environmental after-effects.

The category of high environmental hazard comprises linear sections of oil pipelines in the territory of watersheds of first and second-order tributaries of transboundary rivers and in excessively saturated lands (swamps).

In this case, an oil spill inside the first and second-order tributaries quickly migrates into the main stream of a transboundary river. This period may be less than the time required for the arrival of emergency and rescue services and the organization that works on the spill response.

Oil spill cleaning operations in the territory of the swamps are conducted in harsh natural conditions that require the use of special transport and earthmoving equipment characterized by high off-road performance and additional works-intensive activities to strengthen transport communications and conduct dewatering.

All other sections of oil pipelines where oil spills inevitably lead to certain negative environmental effects are classified as medium environmental hazards.

Therefore, all main pipelines located on the territory of Belarus, in terms of potential environmental hazards, are ranked in four categories. The first three categories include main oil and product pipelines, and the fourth category comprises main gas pipelines:

- The first category is main pipelines with the highest environmental risk.
- The second category includes main pipelines with high environmental risk.
- The third category comprises main pipelines with medium environmental risk.
- The fourth category is main pipelines with low environmental risk.

The evaluation of the additional criteria, related to the relative position of the linear sections of the route and settlements, which determines an increase in the probability of accidents, is done as follows: for linear pipeline sections of the second and third categories (oil pipelines) the proximity of settlements increases the category by one point. It is not necessary to upgrade environmental risk of the first category pipelines (oil pipelines), as they are already characterized by the highest level of potential environmental hazard.

For the fourth category of pipelines (gas pipelines), a higher ranking does not produce a noticeable effect on the level of potential environmental hazard, so level upgrading, in this case, is not appropriate.

The results of the analysis of environmental safety level of the main pipelines in the Republic of Belarus are shown on the map (Figure 2.11).



Environmental risk categories:

- Main oil pipelines with the highest environmental risk
- Main oil pipelines with high environmental risk
- Main pipelines with moderate environmental risk
- Main pipelines with insignificant environmental risk
- Main pipelines with insignificant environmental risk nearby settlements

ПО АДМИНИСТРАТИВНОМУ
МИНСК Столица, город
ГРОДНО Город областного значения и в Гродненской области
УЖЕВ Город областного значения и в Ужвинской области
БРЕСТ Город областного значения и в Брестской области
ЛИТВИН Город областного значения и в Литвинской области

ГИДРОГРАФИЯ И РЕЛЬЕФ
 Реки и каналы
 Озера и водохранилища
 Болота
 Каналы гидротранспорта
 Рельеф: горы и холмы
 Океанические воды

ШКАЛА ВЫСОТ В МЕТРАХ
 0 100 200 300 400 500
 Масштаб 1:1000000
 1:1000000

Chapter III.

Activities of public authorities to ensure safety of the main pipeline transport

3.1. Activities of the Department for Supervision of Safety in Industry to ensure trouble-free operation of the main pipelines

In accordance with Article 15 of the Law of the Republic of Belarus "On Main Pipeline Transport" [2], the principal authority, which conducts state supervision and control of the main pipeline transport, is the Department for Supervision of Safety in Industry within the Ministry of Emergency Situations of the Republic of Belarus (Gospromnadzor). It should be emphasized that the activities of Gospromnadzor are aimed at the prevention of accidents and the reduction of the probability of their occurrence.

This institution was created to improve the efficiency of state supervision of high risk facilities and regulate interactions to ensure safety by Resolution No. 394 of the Council of Ministers of the BSSR as of July 12, 1956, on the basis of the Republican inspection of Boiler and Pressure Vessel Committee of the Main Energy Department with the Council of Ministers of the BSSR. This Resolution established the Committee to oversee the safe conduct of works in industry and mining within the structure of the Council of Ministers of the BSSR (Gosgortekhnadzor BSSR), which was charged with supervision functions in the enterprises of the Republican subordination [68].

Control and supervision of the main pipeline transport in the structure of the Department for Supervision of Safety in Industry with the Ministry of Emergency Situations of the Republic of Belarus are assigned to the Division for supervision of safety of gas supply systems and main pipelines.

To oversee safety issues of gas supply and trunk pipelines systems, Gospromnadzor uses a list of 282 technical regulatory legal acts, over 90 per cent of which are national standards for equipment [69].

The Structure of the Department for Supervision of Safety in Industry with the Ministry of Emergency Situations of the Republic of Belarus is shown in Figure 3.1.

Gospromnadzor performs annual inspections of the facilities under its control for the purpose of monitoring compliance with all standards and requirements of the

regulations. For example, in 2014 the Department for Supervision of Safety in Industry was monitoring 8 680 technical devices of hazardous industrial facilities of the main pipelines, including: 233 gas distribution and gas metering stations; 13 compressor stations with 115 gas pumping units; 25 automobile gas-filling compressor stations with 48 gas compressors; 4 linear production and control stations; 9 oil pumping stations with 102 pumping units; 4 tank farms with 71 tanks; 3 underground gas storage facilities; and 729 pressure vessels [70].

The main pipeline transport facilities occasionally register some deviations from the requirements of the regulations. As a result, the annual checks on the facilities under control by Gospromnadzor detect a few violations. Violation is the fact of non-compliance with the Law "On Industrial Safety of Hazardous Production Facilities" [16] and other regulatory legal acts establishing the rules for works at hazardous production facilities, design documentation, and technical regulations [71]. Figure 3.2 shows the number of violations detected at the facilities of the main pipelines from 2012 to 2014.

Figure 3.1. Number of violations detected at the facilities under Gospromnadzor control

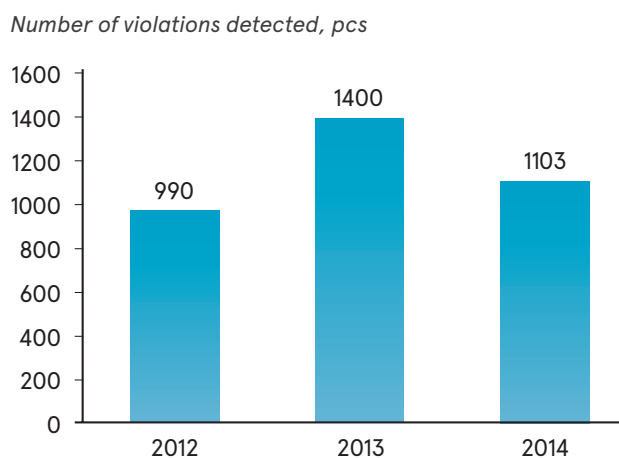
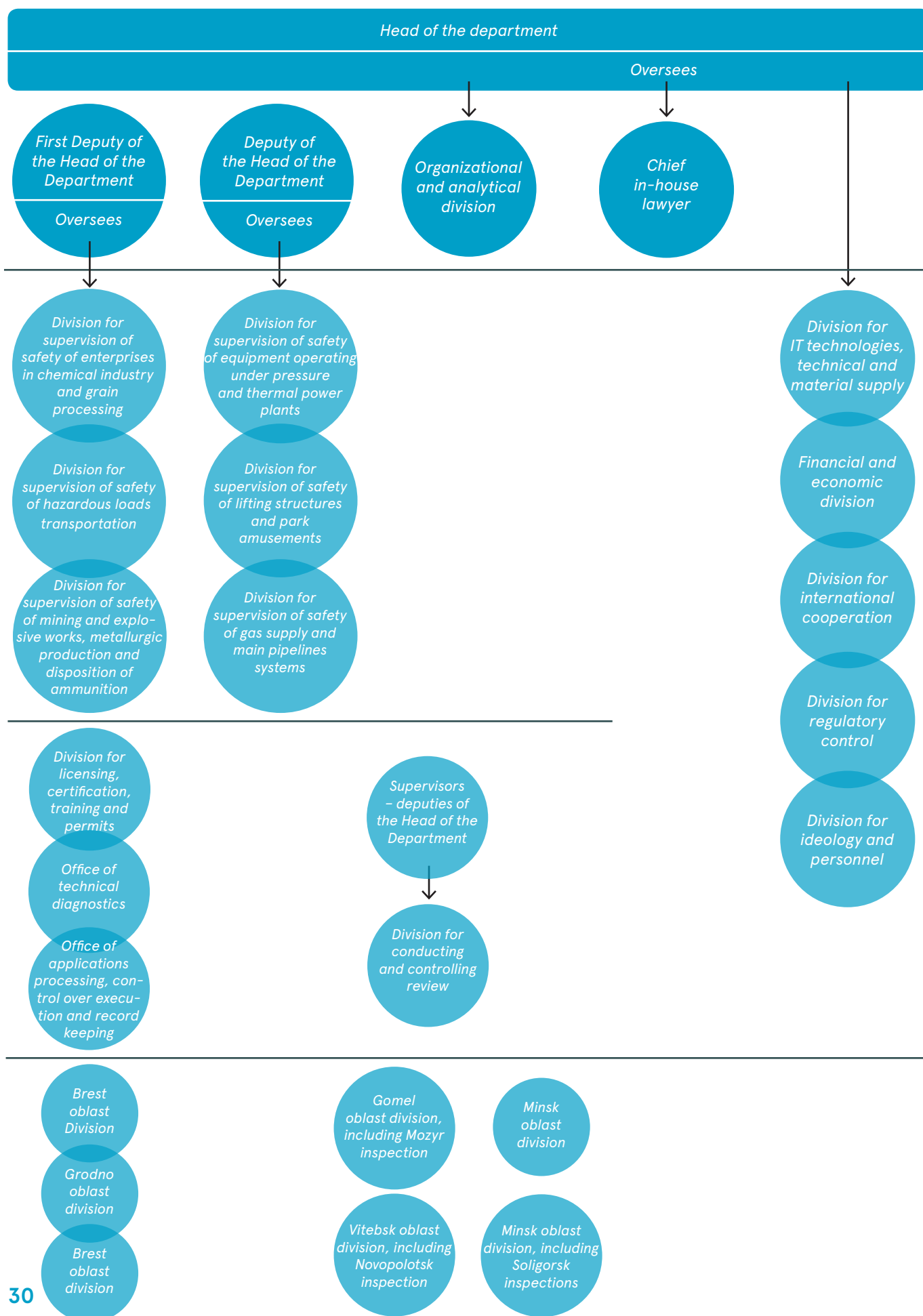


Figure 3.2. Structure of the Department for Supervision of Safety in Industry

The Structure of the Department for Supervision of Safety in Industry with the Ministry of Emergency Situations of the Republic of Belarus (Gospromnadzor)





The most common violations at the facilities of the main gas pipelines, oil pipelines and oil product pipelines during that period are: 1) the presence of shrubs along pipelines; 2) the absence of signs, field guides and information boards; 3) the need for minor repairs (restoration of paint and coatings on the equipment, treatment of partial corrosion, restoration of insulation, recovery of the designed depth of pipelines, 4) the need for additional devices (fillers, fencing, inspection hatch, etc.); and 5) the need to bring working documentation in proper order based on its contents.

Inadmissibility of violations detected is provided for by the technical requirements of technical regulatory legal acts, such as technical codes of practice, state standards and standards of enterprises, industrial safety rules, and others.

At the same time, these violations constitute a deviation from some paragraphs of the Guidelines. Correlating violations with the paragraphs of the Guidelines is a difficult task, since violations are a specific case, and many provisions of the Guidelines are general in nature. Nevertheless, these violations can be associated with some paragraphs of the Guidelines (Table 3.1).

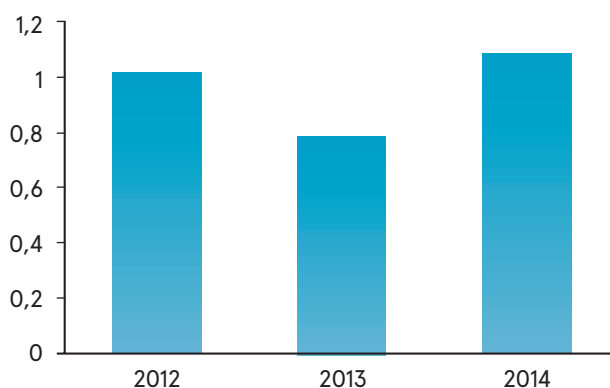
Some deviations from the requirements of the regulations during the future operation of the facility may lead to further incidents or accidents accompanied by the leakage of pumped product out of the pipeline. In such cases, the facility is shut down until the clean-up of the adverse reasons. The number of such violations in the national gas supply and main pipelines system is considerable and does not exceed 1.5 per cent of the total number of violations (Figure 3.3).

Table 3.1. Correlation of violations with the provisions of the Guidelines

Paragraph of the Guidelines	Content
	Recommendations for pipelines' operators
39	Design, construction and operation of pipelines should be carried out, as minimum, in accordance with recognized national and international codes of practice, standards and guidelines, and, where appropriate, internationally accepted specifications of companies
	Annex
D. Protection against corrosion	External corrosion: Surface of underground pipelines must be protected with appropriate coating and provided with cathode anti-corrosion protection; above-ground pipelines must have an acceptable paint or other coating
G. Laying depth	Depth of the underground piping must comply with local requirements in order to minimize the potential impact of external forces
H. Marking	It is necessary to properly mark pipeline routes and locations of their equipment

Figure 3.3. Share of temporary shutdowns out of the total number of detected violations

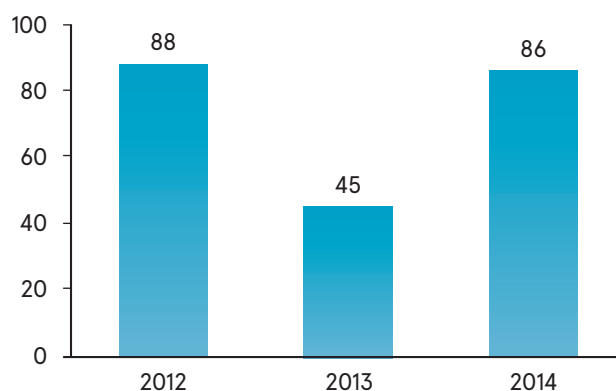
Share of temporary shut-downs out of the number of detected violations, %



Once in a while, as a part of modernization or reconstruction of main pipeline transport facilities, it is necessary to install new, advanced equipment or implement new, innovative methods that are not specified in the current regulatory documents. In such cases, Gospromnadzor approves such deviations. The existence of such approvals may indicate the need for reviewing some current technical regulatory legal acts or for developing new ones based on the requirements of technical progress. The number of the deviations from the regulations approved by Gospromnadzor is presented in Figure 3.4.

Figure 3.4. The number of approved deviations from the requirements of the regulations

Approval of deviations from the requirements, pieces



Violations of the regulations in the absence of response to eliminate them on the part of the operator can cause the onset of an emergency, in which case Gospromnadzor's activity can significantly increase the level of reliability and safety of the main pipelines systems.

Gospromnadzor repeatedly hosts meetings of the Interagency Council on main pipeline transport, which is composed of leading technical experts of the pipeline operators (chief engineers) and representatives of construction, research and design organizations. The Interagency Council

discusses technical and organizational issues to improve reliability and safety of the pipeline systems, proves the urgency of developing new technical regulatory legal acts, exchanges views on the current safety of ongoing technical projects of the operators, etc., which in turn has a positive impact on improving safety of the main pipelines.

3.2. Activities of the Republican special operations unit with the Ministry of Emergency Situations to eliminate the consequences of accidents on the main pipelines

Control activities of Gospromnadzor at main pipeline transport facilities regarding accidents are preventive in nature, aimed at reducing the probability of their occurrence. Emergency Response, depending on the categories involved, is provided by another unit within the Ministry of Emergency Situations.

According to the Law of the Republic of Belarus "On protection of population and territories from emergency situations of natural and man-made disasters" [14], the clean-up of on-site emergencies is carried out by operators. An on-site emergency includes one that affects less than 10 people, or disrupts the conditions of life of no more than 100 persons, or property damage is of more than 40, but less than 1 000 base units on the day of an emergency with the area that does not extend beyond the facility's territory of production or social activities.

The clean-up of republican (state) emergencies is done by forces and means of the republican government and other state organizations, subordinate to the Council of Ministers of the Republic of Belarus.

Article 12 of the Law [14] states that the direct supervision of clean-up of republican (state) and cross-border emergencies is performed by the Republican authority for Emergency Situations – the Ministry of Emergency Situations. A republican (state) emergency is one that affects more than 500 people or disrupts the conditions of life of more than 500 persons, or property damage is over 0.5 million minimum daily wages on the day of an emergency and the area goes beyond two oblasts. Cross-border emergency is characterized by the presence of affecting factors beyond the Republic of Belarus, or an emergency that occurred abroad and affects the territory of the Republic of Belarus.

In the structure of the Ministry of Emergency Situations, the Republican special operations unit is directly involved in mitigation of the consequences of accidents at the main pipelines' facilities. This unit was created by Resolution No. 179 of the Council of the Ministers on May 15, 1991, to conduct top-priority fire and rescue operations by the Ministry of Internal Affairs of the Republic of Belarus [72]. Later this unit was reorganized into the State fire rescue institution "Republican special operations unit" with the Ministry of Emergency Situations of the Republic

of Belarus. From its establishment until the present, the unit has carried out over 4 990 emergency calls. The unit has rescued and evacuated 2 037 persons and eliminated 3 169 emergencies and fires.

The Republican special operations unit eliminates the effects of major accidents at the facilities of the main pipelines and involves teams and oil-gathering equipment of emergency recovery services of operators.

3.3. Activities of the Ministry of Natural Resources and Environmental Protection to ensure environmental safety of the main pipeline transport

The environmental protection system has been operating in the country since 1960 following the establishment of the State Committee of the Council of the Ministers of the BSSR for nature protection (Resolution No. 480 by the Council of the Ministers of the BSSR as of August 29, 1960) [73].

In accordance with the Law of the Republic of Belarus "On Environmental Protection" [12], the Ministry of Natural Resources and Environmental Protection is the republican authority of the government in environmental management and protection, which implements the environmental policy of the state. This Ministry carries out important dynamic policy-making activities aimed at the legal regulation of public relations regarding protection and use of the components of the natural environment and environmental safety of the state.

During normal operation of main pipelines the employees of territorial authorities of the Ministry of Natural Resources and Environmental Protection monitor the state of the environment at enterprises, develop methodology for assessing impacts of operating facilities on the environment, establish the norms of impacts of facilities on the environment, etc. In the event of accidents on the main pipelines, they assess damage to the environment, monitor work on mitigation of after-effects, and provide guidance on emergency response, etc.

3.4. Activities of the Department of pipeline transport, water supply and hydraulics at Polotsk State University to ensure trouble-free operation of the main pipelines

The Department of pipeline transport, water supply and hydraulics at Polotsk State University was created in 1976. The main directions of scientific research conducted at the Department were mainly related to the needs of trunk pipeline transportation of hydrocarbon energy resources.

In 1995, the Department began to train engineers for the main pipeline transport enterprises.

Currently the main scientific area of the Department is ensuring the safety of the main pipelines. Since 1982 the Department has been regularly carrying out scientific and applied research on different issues, including the creation of a scientific and methodological basis for the protection of water bodies in case of accidents on the main oil pipelines [74,75,67], development of technology and equipment for the protection of water bodies during emergency oil spills [76–80], enhancing reliability of underwater crossings [81, 82], and developing a scientific basis for technical regulation of the safety of the main pipeline transport [83, 84].

The specialists of the Department are actively engaged in the creation of new regulations and modification of existing regulatory acts. The Department has developed or updated over 20 regulatory legal acts of different hierarchical levels, including the Law of the Republic of Belarus "On Main Pipeline Transport" [2]. Most of these acts are directly related to the safety of the main pipelines [45–54, 58, 85–88].

In addition, the Department has received 27 patents for technical devices designed to contain and mitigate emergency oil spills.

During the period from 1996 to 2014, the Department organized and hosted eight International Scientific and Technical Conferences called "Reliability and Safety of the Main Pipeline Transport." These conferences have traditionally attracted leading engineers of different companies, scientists, manufacturers, and representatives of various ministries for active discussion of the issues of improving safety and operational reliability of the main pipeline transport.

3.5. Activities of the National Technical Committee 17 on standardization in the field of transportation of gas, oil and oil products to ensure trouble-free operation of the main pipelines

The potential option for the establishment of an authority that would consider the balance of interests of stakeholders in setting technical norms and standardization is provided for in Article 11 of the Law of the Republic of Belarus "On Technical Norm Setting and Standardization" [11]. To develop national standards and technical codes of practice, technical standardization committees can be set up in the form of working groups.

In order to fulfill the requirements of the Law [11], Order No. 207 of the State Committee on Standardization of the Republic of Belarus as of 30.11.2006 established the National Technical Committee (hereinafter – TK17) "Main pipeline transport of oil, gas and oil products" consisting of leading specialists of pipeline and other related organizations to carry out work on the state, interstate and international standardization.

The purpose of the TK17 is the development of technical regulatory legal acts (TRLA) for improving the quality and safety of oil, gas and oil products at main pipelines at the stages of their design, production and operation.

The objectives of TK "Main pipeline transport of oil, gas and oil products" are:

- Reviews and proposals aimed at implementation in the country of unified technical policy in the field of technical norm setting and standardization for the main pipeline transport
- Development and implementation of the TRLA systems in the main pipeline transport of the Republic
- Development and implementation of the national standards of the Republic of Belarus and other TRLA in the main pipeline transport
- Work on interstate and international standardization in the main pipeline transport

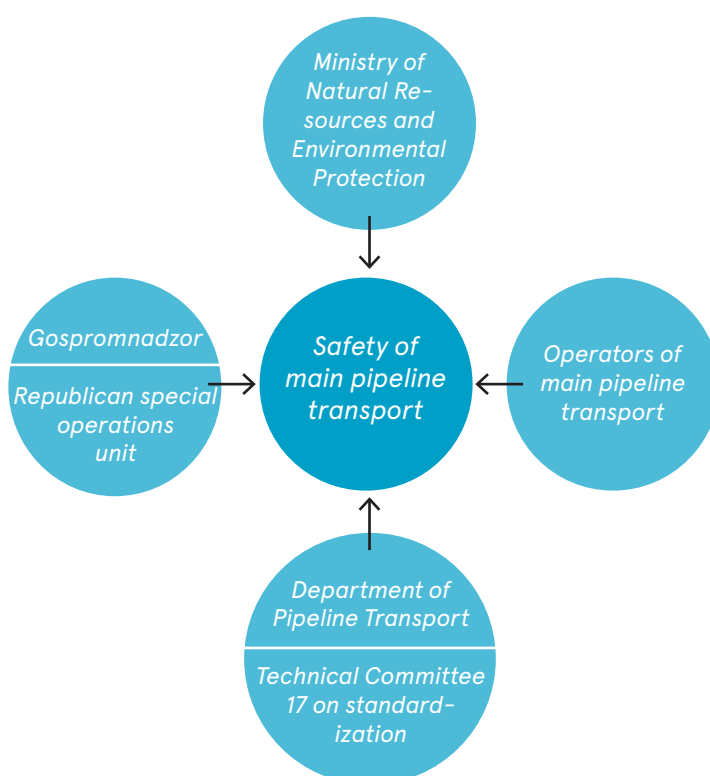
Since 2009, the Secretariat of TK17 has been working on the basis of the Department of Pipeline Transport with Polotsk State University. Over this time and in the course of its activities, the Secretariat of TK17:

- Repeatedly held meetings to address issues of updating technical regulatory legal acts
- Provided monitoring of the status of technical regulatory legal basis in pipeline transport
- Held a taxonomy of technical regulatory legal acts in the main pipeline transport
- Participated in INOGATE international projects "Harmonization of technical standards and practices in the oil and gas sector in Eastern Europe and the Caucasus", during which the Secretariat of TK17 had the European standard document [89] translated into Russian for the Secretariat of the Interstate Council on Standardization, Metrology and Certification of the Commonwealth of Independent States

- Closely cooperated with Russian TK357 "Steel and cast iron pipes and cylinders" with a view to harmonize the Russian standards for piping products in the Republic of Belarus
- Participated in a survey by the Sectoral Initiative WP6 of the UNECE in pipeline safety
- Prepared Draft System of technical regulatory legal acts in the main pipeline transport of the Republic of Belarus, and others

Overall, the analysis of the activities by Gospromnadzor, the Republican special operations unit, territorial authorities of the Ministry of Natural Resources and Environmental Protection, the Department of Pipeline Transport with Polotsk State University, and Technical Committee 17 shows that these units make a significant contribution to improving safety of the main pipelines. The organizational model of ensuring safety of the main pipelines in Belarus is presented in Figure 3.5.

Figure 3.5. Organizational model of ensuring safety of the main pipelines in the Republic of Belarus



Chapter IV.

Analysis of the Recommendations of the Guidelines and Good Practices to ensure pipelines operational reliability within the regulatory framework of the Republic of Belarus

The Guidelines contain 24 recommendations, 6 of which are for the UNECE Member States, 12 for competent authorities and 6 for pipeline operators. Largely, the recommendations include proposals of an organizational nature, and fewer engineering and technical proposals.

The content of the ideas of the Recommendations of the Guidelines, for the most part, repeat or supplement the 11 basic principles of this document. In this regard, a detailed analysis of each recommendation of the Guidelines, within the framework of national regulations, would be inefficient because of possible excessive information load and partial repetition of the material.

The most logical approach seems to be the study of the content of the paragraphs of the Recommendations and the selection for analysis of those whose basic ideas are the most important in terms of safety and, to a lesser extent, duplicate the material described in the Principles and Annexes of the Guidelines. Table 4.1 displays the numbers of selected recommendations for analysis and highlights the main aspects covered by these recommendations.

The basic idea, contained in Recommendation No. 16 of the Guidelines on clear-cut legislation, can be found in the Law [6] of the Republic of Belarus. Article 23 of the Law lists the requirements for national regulations. The

requirements foresee that the regulatory legal acts should be internally approved, logically constructed and comply with the normative technique, and the terms and concepts should be clear and unambiguous. Also, the wording of legal norms of regulations must not be either overly generalized, or overly detailed.

The issue of land-use policies regarding newly designed and commissioned pipelines, which are recommended in paragraphs No. 18, 20 of the Guidelines, are generally found in the Law [2]. In particular, article 16 stipulates that the selection of a pipeline route should be carried out, taking into account natural characteristics of the area, the location of settlements, soil corrosiveness, peat beds, as well as transportation routes and communications, which can have a negative impact on a main pipeline. It is strictly forbidden to lay main pipelines in residential areas, nature reserves, protected areas of national parks, zones of sanitary protection of drinking water sources, as well as unstable geological conditions.

Land-use policy issues are sufficiently presented in [17]. According to this document, it is not permitted to lay pipelines in the territories of residential areas, industrial and agricultural enterprises, airports, railway stations, sea and river ports, marinas, and other similar facilities. When selecting a pipeline route, one should take into

Table 4.1. Analysis of recommendations

No of Recommendation	The main aspect of the Recommendation
16	Clarity of legislation
18, 20	Consideration of land-use policy
18, 20, 31	Consideration of public opinion
19	Availability of competent authorities
22	Permitting procedure
22	Environmental assessment
22, 27	Consideration of transboundary context
23	Availability of inspection system
25, 26, 28	Development of external emergency plans
29, 30, 31	Development of policies directed against third party intrusion
30, 31	Information exchange

account future development of residential and industrial premises, as well as facilities of infrastructure and a pipeline under design for the next 20 years.

In the technical act [17] there are binding minimum distances from pipeline axis and site facilities to settlements, enterprises, buildings and structures. These minimum distances are to be applied, depending on the class and diameter of pipelines, pumping station category, the responsibility degree on the facilities and the need to ensure their safety. As an example, some information on the minimum distances from pipeline axis is given in Table 4.2, and the minimum distances from site facilities (compression stations and gas distribution stations, oil pumping stations) is in Table 4.3. In [17] there are binding minimum distances between parallel pipe runs laid in one technical corridor.

An aspect of public involvement in decision-making in main pipeline transport, contained in Recommendations No. 18, 20 and 31 of the Guidelines are reflected in the following regulatory legal acts [100, 101, 102, 103, 12, 105 and 16].

Article 12 of the Legal act [12] describes the rights and duties of citizens in environmental protection. Under this article, citizens are entitled to:

- Create NGOs working in environmental protection, and set up public environmental funds
- Apply to the state authorities, other organizations and public officials and receive full, accurate and timely information on the state of the environment and measures for its protection
- Take part in the preparation and discussion of materials on environmental impact assessment of the planned economic and other activities
- Carry out public control in environmental protection and other

Table 4.2. Minimum distances from pipeline axis to facilities

Minimum distances, m, from axis											
Gas pipelines						Oil pipelines and oil product pipelines					
class						class					
I						II		IV	III	II	I
Nominal diameter, mm											
300 and less	over 300 to 600	over 600 to 800	over 800 to 1000	over 1000 to 1200	over 1200 to 1400	300 and less	over 300	300 and less	over 300 to 500	over 500 to 1000	over 1000 to 1400
100	150	200	250	300	350	75	125	75	100	150	200

Facilities, buildings and structures

Towns and other settlements; communal gardens with summer houses, country houses, individual industrial and agricultural enterprises; hot house businesses; poultry farms; milk factories; mineral deposit open casts; garages and open car parks for private owners for more than 20 cars; separate buildings with large number of people; 3 and more floor residential buildings; railway stations; airports; sea and river ports and quays; hydropower stations; hydro-technical structures of sea and river transport of I-IV classes; treatment structures and pumping stations, water pipes, separate from main pipelines; railway bridges of common network and roads of I and II category with over 20 m span; warehouses with easily flammable and combustible liquids and gases with storage volume over 1 000 m³; car filling stations; masts and structures of multi-channel radio line of technological communication of pipelines; masts and structures of multi-channel radio line of technological communication, TV towers

Table 4.3. Minimum distances from on-site facilities.

Minimum distances, m								from pumping stations		
from compressor stations and gas distribution stations								Pumping station category		
Gas pipeline class										
I								I		
Gas pipeline nominal diameter, mm										
300 and less	over 300 to 600	over 600 to 800	over 800 to 1000	over 1000 to 1200	over 1200 to 1400	300 and less	over 300	III	II	I
500 150	500 175	700 200	700 250	700 300	700 350	500 100	500 125	100	150	200

Facilities, buildings and structures

Towns and other settlements; communal gardens with summer houses, country houses, individual industrial and agricultural enterprises; hot house businesses; poultry farms; milk factories; mineral deposit open casts; garages and open car parks for private owners for more than 20 cars; separate buildings with large number of people (schools, hospitals, clubs, nursery schools, railway stations, etc.); 3 and more floor residential buildings; railway stations; airports; sea and river ports and quays; hydro-power stations; hydro-technical structures of sea and river transport of I-IV classes; treatment structures and pumping stations; water pipes separate from main pipelines; railway bridges of common network and roads of I and II category with span over 20 m; warehouses of easily flammable and combustible liquids and gases with storage volume over 1 000 м³; car filling stations; masts (towers) and structures of multi-channel radio line of technological communication of pipelines; masts (towers) and structures of multi-channel radio line of technological communication, TV towers

Article 15 of the Law [12] describes the rights and obligations of NGOs working in the field of environmental protection. The legal basis for the creation and activities of such organizations are presented in legal act [105]. The rights of NGOs in the field of environmental protection include:

- Participation in the drafting of state, sectorial, local and other programmes and activities on the rational use of natural resources and environmental protection and facilitation of their implementation
- Submission of proposals on environmental protection issues and rational use of natural resources to the public authorities and other officials
- Participation in the preparation and discussion of materials on environmental impact assessment of the planned economic and other activities, e.g., by holding public hearings
- Organizing and conducting, in accordance with established procedure, public environmental review
- Exercising public control in the field of environmental protection

- Applying, under the procedures established by the legislation of the Republic of Belarus, to the state bodies, other organizations and public officials and receive full, accurate and timely information on the state of the environment and measures for its protection
- Addressing the state bodies and other organizations with complaints, applications and proposals on matters relating to the environment, adverse environmental impacts, and obtaining timely and grounded responses
- Addressing in the mass media environmental and other issues

Article 4 of the Law [100] guarantees the right of individuals and legal entities to a healthy human environment during architectural design, urban planning and construction activities. The exercise of this right provides for the opportunity to participate in public hearings.

In accordance with the Law, the state authorities, legal entities, and public officials are required to provide an

individual with the opportunity to be informed on matters affecting his/her rights and legitimate interests in the event of architectural design, urban planning and construction activities.

The customer, developer, and contractor shall make available the information about a facility with indication of the customer, developer, and contractor, dates of beginning and completion of construction, installation, and commissioning and other information.

Republican state administration authorities, local executive and administrative bodies and organizations of state construction supervision are to inform individuals and legal entities about architecture design, urban planning and construction activities through the media and other sources.

A detailed presentation of the concept and organization of public discussion is given in [101].

Public discussion is carried out prior to the state examination. Such discussions have the form of:

- Informing individuals and legal entities, and analysis of public opinion
- Commission's activities on organization of public discussions

The organizer of the public discussion is the regional, district, municipal, town, or village executive committees or local district government in the city. A notice for public discussion must be placed by the organizer on the official website of the local executive and administrative body in the Internet global computer network, bulletin boards of this authority, in the media, on bulletin boards at residential entrances, at least ten calendar days before the start of public discussion.

The period for public hearing is 25 calendar days, including the duration of project presentation, which is 15 calendar days.

As indicated in [101], in the framework of public discussion they can have independent professional review for the purpose of independent assessment of compliance of design solutions with requirements of regulatory legal acts and technical regulations. Professional independent examination is not mandatory and is conducted on the initiative of participants in the public hearing.

In addition to the public discussions on the issues of land-use planning during design of main pipeline transport facilities, in a number of cases, there is public discussion of project design documentation section, i.e., environmental impact assessment. This public discussion is conducted with the people whose rights and legal interests may be affected by design solutions. General information on public discussions of the project design documentation, which requires environmental impact assessment, is presented in [102].

Article 13 of the Law identifies facilities, which must have environmental impact assessments at the project design documentation stage. They include such major pipeline transport facilities, as:

- Oil and gas pipelines with a diameter of 500 mm and more
- Warehouses for storage of 50 000 cubic metres of oil and more
- Underground gas storage facilities

Issues related to the organization of public discussions of environmental impact assessment is regulated by [103]. The procedure of public hearings includes public notification of forthcoming public discussions, public access to environmental impact assessment reports held by the customer and at the local executive and administrative bodies, study of the report by the public. In the event of general interest, the public is notified about the date and place of the meeting where the report will be discussed.

The relevant local executive and administrative bodies, together with the customer, at least three working days before the publication of the notice of public discussions, sets up a commission for the preparation and conduct of public discussions. The meeting to discuss environmental impact assessment reports is not held unless public representatives apply to the relevant local executive and administrative authorities with an application about the necessity of its holding within 10 working days from the date of publication of the notice of public discussions.

In addition to the public hearing on project design documentation section containing environmental impact assessment, it is possible to conduct public environmental review of project design documentation, which is stipulated by the legislative act [12]. Article 61 of the Law states that public environmental review is organized and conducted, on the initiative of NGOs and citizens, by independent experts, who are entitled to receive from the future operator the project design documentation and materials subject to public environmental review, including environmental impact assessment materials.

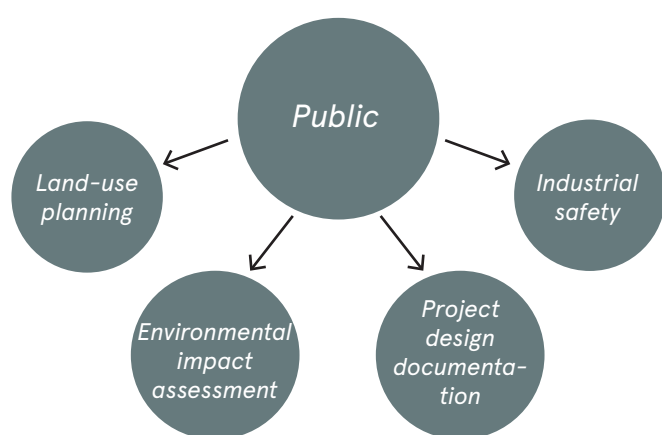
The conclusions of public environmental review can be directed to the organizations that carry out state environmental examination, local executive and administrative authorities, as well as other stakeholders, and are treated as recommendations.

The details of public environmental review are listed in [104]. This Provision indicates that before public environmental review of project design documentation, within ten working days from the date of publication of the notice of public discussions, the initiators send to the customer an application about their intent to conduct public environmental review. To this end, the initiators involve specialists who have appropriate qualifications and experience in the field of the review to be conducted. The results of public environmental examination are presented by these experts in the form of the conclusions of the public environmental review regarding project design documentation.

Apart from participation in the environment monitoring through public debates, the public can participate in industrial safety monitoring issues. Articles 22 and 23 of the Law [16] state that NGOs have the right to exercise monitoring over compliance with industrial safety. NGO representatives are entitled to access the territory of organizations operating hazardous production facilities.

Therefore, the subject areas that are affected by public opinion in decision-making in the environmental safety of the main pipeline transport can be represented as a diagram in Figure 4.1.

Figure 4.1. Areas of public opinion impact



The aspects of Recommendations 19, 22, 23 of the Guidelines on the availability of competent authorities, permitting procedure, inspections, and environmental assessment should be combined and reviewed in a single context. Such a combination of four aspects into one is due to the fact that the competent authorities issue permits (review, licences) to the operators for project design documentation, for various types of works at different stages of the life cycle of main pipelines and conduct regular inspections of operating facilities, with environmental assessment being conducted as early as at the stage of project design documentation development for future facilities. It is logical to review the procedures for issuing permits by the competent authorities at such life cycle stages as the design, construction and operation of trunk pipelines.

Basic and supplementary regulations at the stage of main pipeline transport design, which describe design process organization, requirements for project design documentation, project design documentation content, algorithm of action sequence and other, are [100, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115 and 116.

At the beginning of the organization of future main pipeline designs, the customer chooses a project management scheme in accordance with the album of drawings, which determine the sequence of actions in the implementation of an investment project in construction [117]. As indicated in [106], before the development of project design documentation for construction, reconstruction and

restoration of construction sites that are attributable, in accordance with the classification under [118], to the first-fourth grades of complexity, predesign documentation is developed and approved.

The basis for a decision on the attribution of a building or structure to a certain complexity class is its technical characteristics (height, volume, area, capacity, length of the building or structure, and others.). As additional criteria, they consider functional purpose of buildings and structures, their technical and economic characteristics, and projected economic, social and environmental effects in the event of an accident at the facility. According to paragraph 5 [118], main pipelines belong to the first complexity class K-1.

The results of the predesign stage are the basis for a decision on the implementation of an investment project, obtaining of the land documentation for the construction of a facility and conducting design and survey works.

Predesign documentation for a newly constructed trunk pipeline is as follows:

- Declaration of intent
- Feasibility study of investments and a project management plan
- Business plan
- Design assignment

The declaration of intent is submitted by the customer, along with an application for obtaining a land plot, to the local executive authority. With these documents, the customer informs the local authority about the characteristics of a planned construction project. The list of information given in the declaration of intent includes the location of a facility, its technological data, estimated need for labour, water, electricity, heat, land resources and the justification for a plot size. The customer provides the declaration of intent with the specifications for engineering support (telephones, radio, electricity, gas, heat, etc.), of a future facility, approved by organizations licensed to provide such services. The list of organizations and terms of the approval of technical conditions are discussed in [119]. After studying the declaration of intent, the local executive authority gives preliminary approval for land plot placement.

Feasibility study of investments should contain the following sections:

- 1) Investment objectives
- 2) General characteristics
- 3) Facility capacity
- 4) Principal technological solutions
- 5) Procurement of raw materials, auxiliary materials, semi-finished products, packaging and wrapping materials
- 6) Architectural and planning concept
- 7) Environmental impact assessment
- 8) Staffing and social development
- 9) Project budget; investment performance
- 10) Conclusions and proposals

During development of the investment feasibility study, one should have an alternative study and calculations for all proposed land plots, calculations to determine investment performance, social, environmental and other effects of the construction and operation of the facility, as well as calculations of losses of landowners, agricultural production losses associated with the removal of land, etc.

The business plan describes ways to achieve projected technical and economic indicators of a facility under construction. This document is developed with available lending resources and approved in accordance with [116]. When the customer uses funds from the national budget, budget loans, state support, etc., the business plan of an investment project, according to [116], is subject to compulsory State expert examination conducted by the Ministry of Economy to prepare a conclusion on the appropriateness of state support to implement such an investment project.

According to [106], the content of sections and the list of requirements to be included in design assignment are determined by the customer and can be specified in the contract agreement for preparation of design and survey works. Design assignment is included in the tender documentation for selection of a design organization.

Design assignment contains information about construction, funding sources, technical and economic indicators, technical conditions, conclusions of state bodies (Gospromnadzor, etc.), permits and others. A tentative list of contents of design assignment, recommended in [106], comprises 31 paragraphs and the Annex to design assignment, 49 paragraphs. Permits for design assignment include acts for land selection, decisions on removal and allocation of a land plot, permits for design and survey works, and technical conditions for engineering networks of a facility.

Simultaneously with the development of project design documentation, the customer can get from the local authorities a final approval for a land plot for future facility construction. General issues of regulating land relations with the indication of categories and types of land are considered in [10], and the procedure for removal and allocation of land plots is described in [120].

According to [120], land for construction and maintenance of linear structures (gas, oil) within the boundaries of these facilities' buffer zones out of the lands of nature protection, health recovery, recreational, historical and cultural, forestry purpose, is provided for permanent use or lease.

Removal and allocation of land plots, required for the construction period of underground linear structures (gas and oil pipelines), carried out within the boundaries of protected zones of these facilities within the time frame that does not exceed a year and a half, and not accompanied by cutting down trees and shrubs, is not required. The construction of such facilities is carried out on the basis of land cadastral documentation and acts for selec-

tion of land plots, and calls for compensation for damages and losses in agricultural and forestry production.

The customer, pursuant to the approved act for land plot selection, performs design and survey works. Engineering surveys provide a comprehensive study of natural conditions of a projected construction site to obtain the necessary inputs. Survey works provide for the study of composition and types of soil in this area, determine groundwater level, measure background concentrations of environmental pollution, etc. The conduct and content of the works of engineering surveys are regulated by the following technical regulatory legal acts [121, 122, 123, 124, 125].

Survey materials and data should be sufficient to justify the possibility of placement of designed facilities, taking into account the rational use and protection of the environment, and to make forecasts for its changes, because of the planned activity for the construction and operation of facilities. Engineering surveys are divided into the following types: engineering geodesic, engineering geological, engineering geo-environmental and engineering hydrometeorological [123]. Engineering surveys shall be registered with the local architecture and urban planning organizations or others.

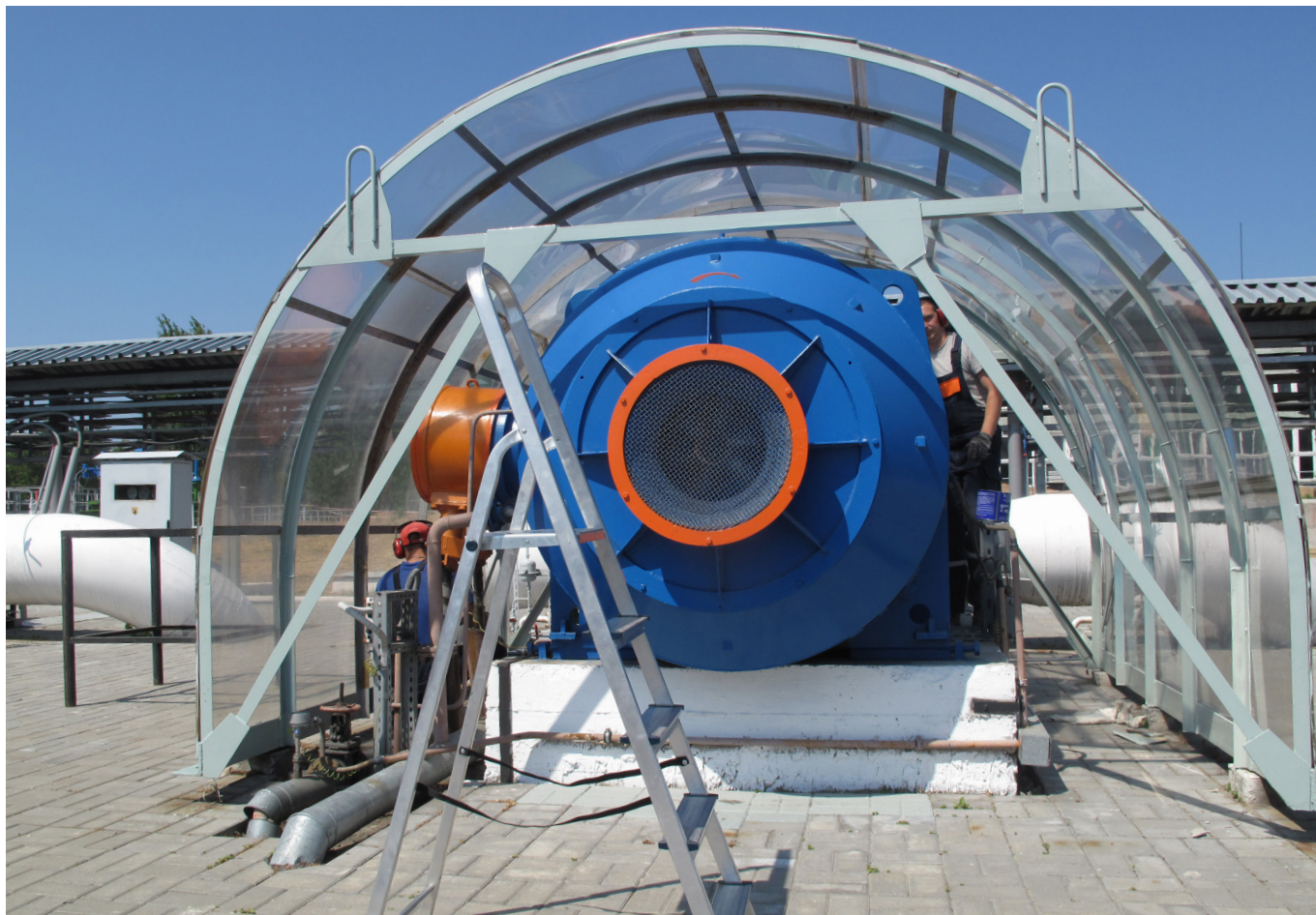
Prior to approval of predesign documentation, the customer shall submit:

- Architectural and planning concept of a facility under construction for public discussion in accordance with [101]
- Investments feasibility study for environmental impact assessment, in accordance with [102, 104], conducted by departments of the Ministry of Natural Resources and Environmental Protection

The final stage of predesign work is the state review, after which the project design documentation can be approved by the customer. Feasibility studies of investments in the construction are done by the Republican Unitary Enterprise "Glavgosstroyekspertiza" with the State Committee for Standardization.

The main provisions of the procedure of this examination are given in [100, 101]. The term of the state examination shall not exceed one month. The state review shall control:

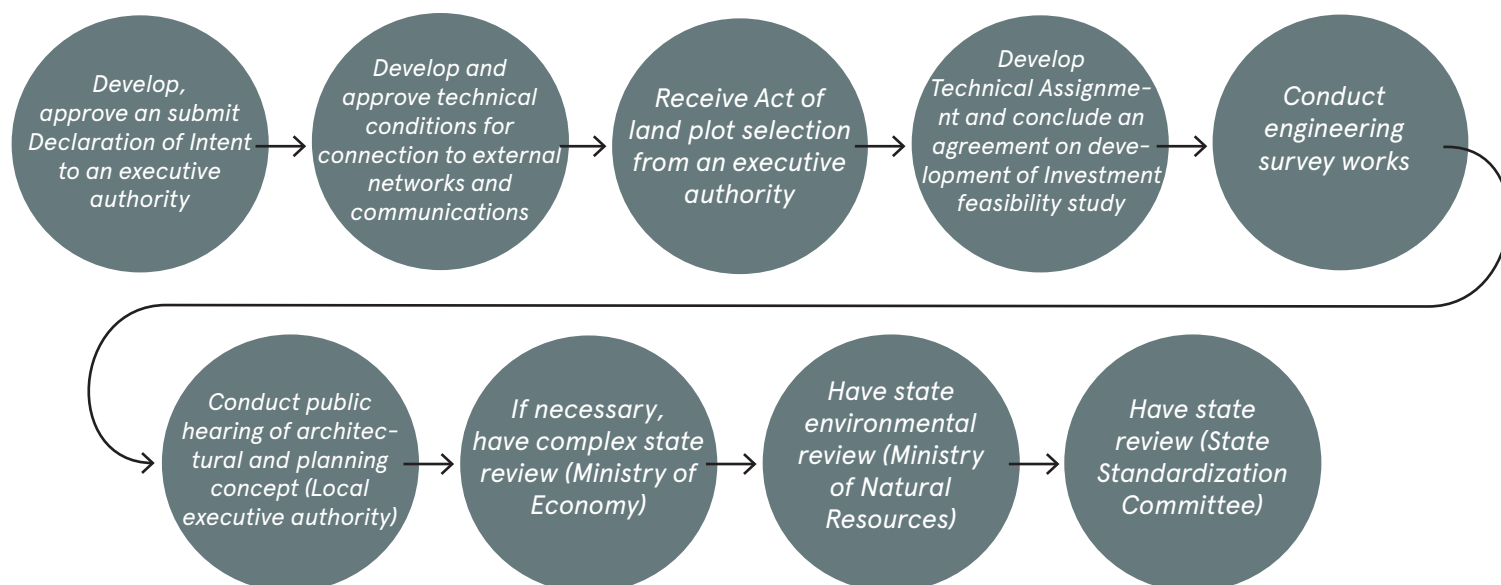
- Completeness and validity of the design
- Compliance with the requirements of operational safety and reliability of basic design solutions, fire and explosion safety
- Compliance of design solutions with the requirements of labour safety regulations, sanitary norms, rules and hygienic standards
- Energy efficiency of technical solutions
- Availability of sound technical solutions and measures for rational use of natural resources, pollution prevention, emergency prevention and emergency response
- Feasibility and economic efficiency of the planned construction and others



Therefore, the organization of the process for predesign documentation development in simplified form (without some of these steps in parallel and additional approvals of documentation with Gospromnadzorom, fire supervision, energy efficiency supervision, health supervision, labour protection supervision) can be represented in Figure 4.2 as a chart.

Project design documentation is the basis for construction financing. The next step in the realization of the intentions of the customer to construct main pipeline transport is the development of project design documentation. The principal and supplementary information on the composition and content of project design documentation is contained in the following acts [100, 107, 108, 109, 112, 113].

Figure 4.2. Organizational chart of predesign stage



In [107] there is an indication that project design documentation development can be done in one or two stages. In case of two-stage designing, architectural design and construction design are being developed. During one-stage designing they develop a construction design.

The architectural design is developed on the basis of approved urban development designs, engineering research materials, permits and predesign documentation. The architectural design of facilities under construction consists of the following sections:

- General plan and transport
- Technological solutions
- Organization and conditions of work of employees
- Engineering equipment, networks and systems
- Construction management
- Environmental protection
- Engineering civil defense measures
- Cost estimates
- Investment performance or main technical and economic indicators
- Energy efficiency

The construction design in a two-stage process is developed on the basis of the approved architectural design and engineering research materials. The construction design is being developed to the extent necessary and sufficient for the construction and installation works. The construction design, including all major sets of working drawings, is submitted to the state examination and must be approved by the customer on the grounds of the expert opinion. The composition of construction design must comply with the requirements specified in [108].

The construction design documentation includes:

- Drawings of construction and installation works
- Design documentation for construction products
- Sketch drawings of general types of non-standard products
- Specifications for equipment, products and materials
- Cost estimates per established forms and others

Project design documentation, in accordance with [101, 104], must have environmental and state examinations, approvals and permits for construction and installation

works. Issuance of permits for construction and installation works under [126] on construction sites is provided by the inspections of the Department of Control and Supervision in Construction with the State Committee for Standardization.

A simple organization chart of project design documentation development is shown in Figure 4.3.

Prior to facility construction, works for construction preparation should be completed. General organizational and technical preparation should be carried out, in accordance with [127], and include:

- Availability of project design documentation
- Allocation in kind of land for construction
- Execution of construction financing
- Conclusion of construction contracts and subcontracts for construction
- Obtaining of permits and pass tickets for work performance and others

The contractor should prepare for construction and installation works and do as follows:

- Obtain a licence to perform licensed construction and installation works
- Have certified professionals, responsible for construction and installation works (chief engineer, superintendent and others)
- Obtain and verify project design documentation, as specified by regulations
- Draft the work performance plan
- Have fixed marks on the ground of horizontal and vertical points of a construction site, as transferred by the customer and accepted by the contractor
- Develop and implement measures to ensure the organization of labour and provision of construction teams with flow charts and others

The construction of each facility should be based on previously developed construction management projects and works performance plans, decisions on construction arrangement and technological charts. Regulations that define the main aspects of construction, working time norms, labour safety, etc. are [128, 129, 130, 131, 132, 133, 134].

Figure 4.3. Organizational chart of project design stage

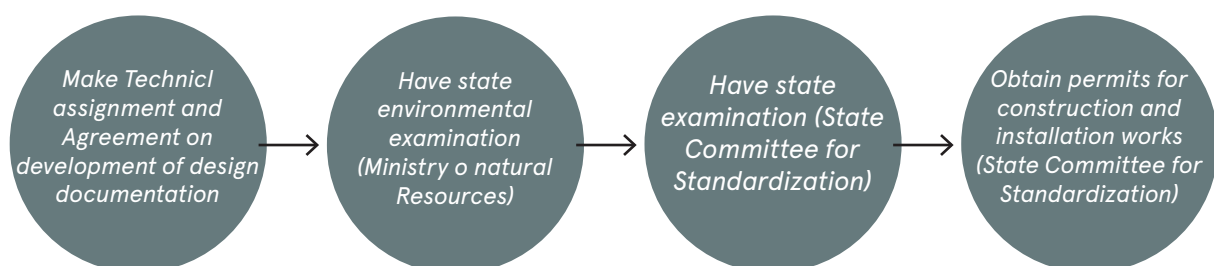
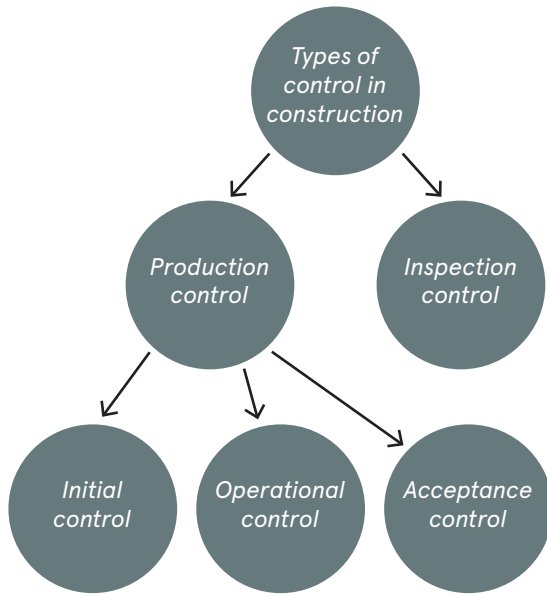


Figure 4.4. Types of control in construction



Documentation for the organization of construction and works performance includes construction management projects of a facility and works performance plans. A construction management project is developed as part of the investment rationale of construction, architectural design or construction design.

A construction management project is the basis for the drafting of a works performance plan. Works performance plans are developed by the contractor on the basis of architectural or construction designs. The contents of a construction management project and works performance plan are specified in [128].

According to the information contained in [135, 136], all construction sites are divided into three levels of responsibility: high, normal, and low. According to these documents, sites that, by the provisions of the Law [16], are included in the list of hazardous production, are categorized as high responsibility level I, which is characteristic of the main pipeline transport.

Organizations working in construction must have a production control system, which includes [133]:

- Personnel responsible for the quality control of products
- Required monitoring tools
- Working environment (premises, transportation, communication and so on)
- Technical regulatory legal acts regarding quality control and product requirements
- Quality management system documents

Production control systems shall undergo assessment procedures that allows, in case of positive results, for obtaining a technical competence certificate. This certificate confirms that the authorities of a construction company can carry out construction quality control and ensure construction safety.

Production control shall ensure the monitoring of production in construction during all manufacturing stages by means of initial, operational and acceptance control. In some cases, there can be an inspection control. Quality control of construction and installation works must be carried out by personnel and special services that are a part of a construction company, and equipped with technical tools. Types of control are shown in Figure 4.4.

The initial control is conducted in accordance with [137].

The control verifies: the completeness of project design documentation; geodesic breakdown data being compliant with established requirements for accuracy; compliance of products, materials and equipment with standards, specifications and other supporting documents confirming their quality. The results of the initial control should be recorded in the log of initial control.

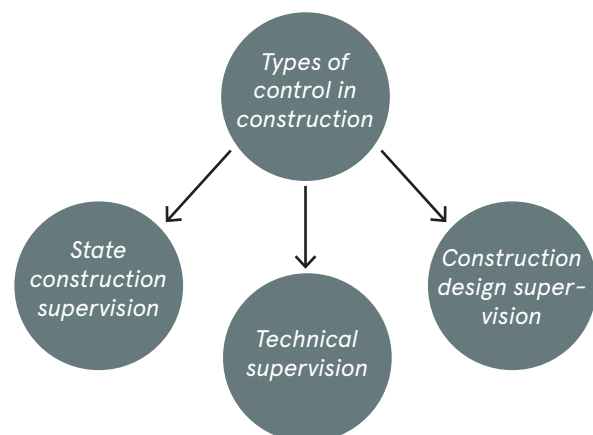
Operational controls should be carried out both during and after production operations in order to ensure timely detection of defects and measures to remove them. During operational control, one should verify compliance of technology for construction and installation works, compliance of works with project design documentation and requirements of technical regulations. The results of operational control should be recorded in the log of works performance.

During acceptance control, the quality of performed construction and installation works, as well as the quality of critical structures should be checked.

Inspection control over the activities of a company, certified in the production control system, is done by an organization engaged in evaluation of production control systems, and which has been issued a technical competence certificate. Inspection control is carried out in the form of scheduled and unscheduled inspections.

During construction work, the mandatory supervision over works performance is held [100, 128]. Types of supervision in the construction industry are presented in Figure 4.5.

Figure 4.5. Types of supervision in construction



State construction supervision is carried out by the Department of control and supervision in construction within the State Committee for Standardization. The activities of the units of the state construction supervision are regulated by the following acts [100, 138].

The authorities of the state construction supervision:

- Check the availability of documents by the customers and developers at construction sites
- Monitor compliance with the requirements of technical regulations in construction, approved project design documentation for construction and installation works
- Check the compliance of materials, products and structures used in construction with design solutions and certificates for operational reliability and safety
- Study appeals of individuals and legal entities on matters within their competence and others

Principal provisions of technical supervision procedures are described in [139]. As indicated in this document, the customer provides technical supervision from the beginning to the completion of construction and commissioning. A representative of technical supervision is appointed by an order of the customer from his staff; or an engineering organization is involved under the engineering contract. A representative of the technical supervision records his/her comments on defect detection in the logs of works performance.

A technical supervision specialist should:

- Control the presence of executive documentation and proven measuring instruments on construction sites
- Participate in the transfer of geodesic control network to the contractor
- Monitor individual testing of installed equipment by the contractor
- Check the quality of construction and installation works, materials used, products, structures and equipment
- During commissioning and its preparation check the actual readiness of each type of works
- Check the availability of production and executive documentation and other

The procedure for construction design supervision is contained in the Act [140]. The construction design supervision is done by the developer of the architectural or construction design in order to ensure that the architectural, technological and other technical solutions and technical and economic indicators of commissioned facilities comply with design solutions and indicators.

The construction design supervision is performed based on the agreement concluded between the customer, developer and architectural or construction designer. In the process of the construction design supervision, the PDD developer fills out the log of the construction design supervision.



After the completion of construction, facilities have to be commissioned; the relevant information for this procedure is given in [141]. During commissioning an acceptance committee is established. The acceptance committee is created out of representatives of the customer, general contractor, general designer, operator, and supervisory organization.

Before commissioning, a working committee meeting to accept equipment, after comprehensive testing of a facility as a whole, must be held.

The compliance of a facility with approved project design documentation and requirements of operational safety and reliability must be confirmed by state supervision authorities:

- Ministry of Natural Resources and Environmental Protection of the Republic of Belarus
- State sanitary inspection within the Ministry of Health of the Republic of Belarus
- Department of control and supervision in construction within the State Committee for Standardization of the Republic of Belarus
- Department of the State Labor Inspection under the Ministry of Labor and Social Protection of the Republic of Belarus
- Department of Supervision over Safety in Industry within the Ministry of Emergency Situations of the Republic of Belarus
- Ministry of Emergency Situations of the Republic of Belarus.

The acceptance committee shall check: compliance of facilities and installed equipment with project design documentation, construction and installation works in accordance with current technical regulations; test results and comprehensive testing of equipment; measures to ensure working conditions under the requirements of fire safety, industrial hygiene and environmental protection; the availability and content of the documentation attached to the act, and the findings of the state supervision.

The customer submits to the acceptance committee the following documentation:

- Approved project design documentation;
- A list of design, R&D organizations involved in the design of a facility
- Documents for the use or ownership of land
- Conclusion of the state independent and state environmental assessment of project design documentation
- Permits for construction and installation works
- Documents for geodesic control network or construction
- Documents for engineering geological and hydrogeological survey of a construction site
- Passports for equipment and machinery
- Technical specifications for engineering and technical supply of a facility
- Conclusion of the state supervision authorities about compliance of a commissioned facility with approved project design documentation

Commissioned facilities enjoy a 2-year warranty period. The warranty period starts from the date of approval of the act of acceptance of a commissioned facility.

Commissioning, in accordance with [142], is the basis for the creation of state registration of capital assets. The investor has to have the state registration of a commissioned facility, receive an inventory number and the cadastral map showing the territory of the corresponding registration district, land plot boundaries, easements, protected zones, and location of permanent buildings.

To receive services of transportation of energy resources and operation of pipelines, the customer shall have a licensing procedure and receive a licence (permission) to carry out activities. Licensing in the main pipeline transport and in other areas is governed by the act [143].

Due to the fact that main pipelines are hazardous production facilities, the customer (operator), after completion of pipeline construction, shall execute its planned activity in industrial (production) safety. Licensing of activities in production safety is done by the Ministry of Emergency Affairs.

A licence is issued for a specific activity with indication of works and services that make up this type of activity. To obtain this licence, the applicant or his/her authorized representative shall submit to the appropriate licensing authority an application for a licence with an indication of the planned types of works.

Among the list of activities, which require a licence in industrial safety, [143] indicates:

- Operation of hazardous production facilities under the Department for Supervision of Industrial Safety in Industry
- Design, installation, commissioning, maintenance, diagnostics, repairs of technical devices
- Design, installation of facilities of trunk oil and gas pipelines, oil product pipelines, gas distribution systems and gas consumption

In case of a positive conclusion, a licence is issued for a period of five years.

Before making a decision on licensing, the Emergency Situations Ministry arranges the examination of compliance of the capabilities of a licence applicant with licensing requirements and conditions, and assesses the capability of the applicant to carry out the declared jobs. Requirements for the examination of industrial safety and drawing an review conclusion are contained in [144]. The list of facilities subject to examination includes those of trunk pipeline transport. The aim of the examination is to determine the compliance of the state of the hazardous production facility with the requirements of the legislation on industrial safety.

The expert conclusion on the results of the examination presents substantiated findings in the compliance of the

state of a hazardous production facility with the requirements of the legislation in the field of industrial safety. These conclusions are based on the evaluation criteria of industrial safety of hazardous facilities. If examiners must assess facility compliance with industrial safety requirements, they apply the following score system: "good", "satisfactory", and "critical".

In assessing the state of industrial safety of hazardous production facilities, the following main criteria are considered:

- Compliance with the industrial safety requirements for design, construction and commissioning of hazardous production facilities
- Compliance with the industrial safety requirements for technical devices used at hazardous production facilities
- Readiness for action to eliminate accidents at hazardous production facilities

The customer (operator), before commissioning, shall have trunk pipeline registered in the state register of hazardous production facilities to ensure proper accounting and industrial safety control. For this purpose, he submits an application to the registration authority. The main provisions of the registration process are described in the following acts [145]. Registration of facilities in the state register is performed by the Department for Supervision of Safety in Industry.

Registration in the state register foresees identification of facilities under the act [146]. The identification is based on hazardous features and limiting amounts of hazardous substances. The identification process has to identify all facilities, all dangerous signs and determine the type of each facility operated by a company.

Hazardous production facilities are classified by hazard degree into three types. Classification criteria are con-

tained in [16, 146]. According to this classification, one of the criteria for classifying a facility as the most hazardous (type I) is the amount of hazardous substances in warehouses of 50 000 tonnes and 200 tonnes in the main pipeline. Based on these values, a pipeline section of nominal diameter of 1 000 mm and length of 300 metres with oil inside can be categorized as a hazardous industrial facility of hazard type I.

The identification is done by the organization operating a hazardous production facility or an expert organization with a relevant permit. The result of the identification of a facility is an accounting file of a facility in the state register.

In addition, the operator, before commissioning, must complete the declaration procedure for the safety of trunk pipeline facilities, followed by the development of a safety declaration. A safety declaration for an existing production facility is a mandatory document that is submitted to Gospromnadzor to obtain a licence to carry out various activities.

The procedure for safety declaration development for hazardous production facilities is presented in [147]. According to this document, a safety declaration is mandatory for designed and operating hazardous industrial facilities, which includes main pipelines.

The safety declaration is developed independently by a company that operates highly hazardous productions, or under the agreement with a specialized organization licensed by Gospromnadzor to develop safety declarations of these productions. This document is to be reviewed no less than once every five years.

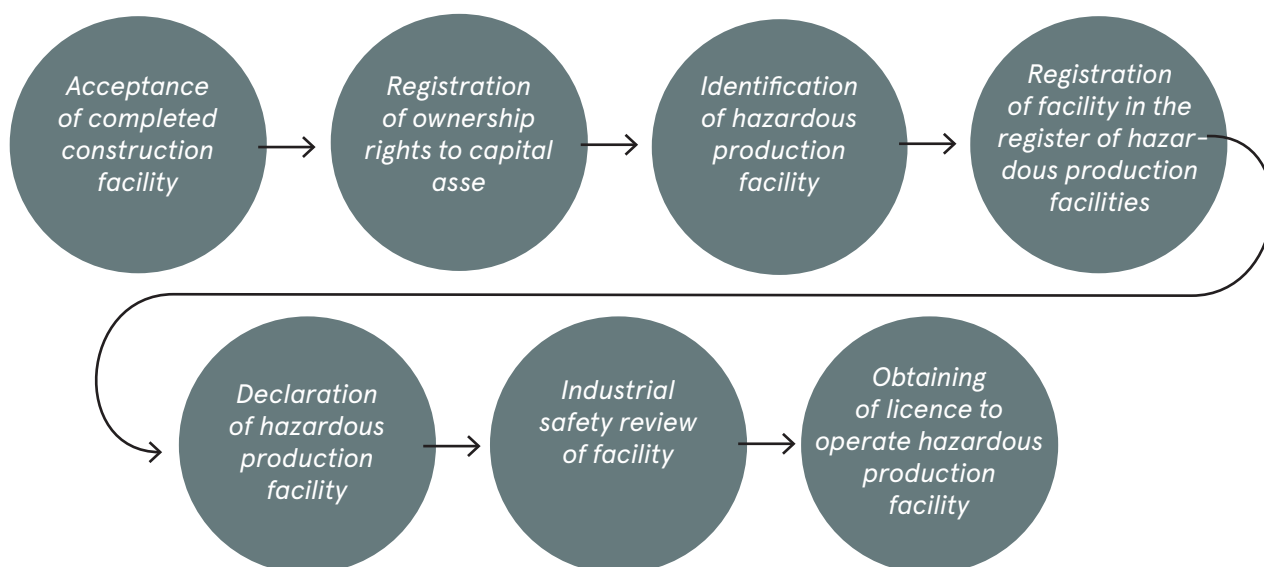
The safety declaration of a production facility is done to ensure control over safety measures, assess the sufficiency and efficiency of measures to prevent and eliminate emergencies at a production facility. The main sections of this document are presented in Table 4.4.

Table 4.4. Main sections of safety declaration of a hazardous production facility

Section	Content of section
General information	1. General information about the production facility 2. General safety measures
Analysis of production facility safety	1. Data on technology and machinery 2. Analysis of hazards and risks 3. Measures to ensure safety and emergency tolerance
Guarantee of readiness of production facility to contain and eliminate emergencies	1. Description of emergency warning system 2. Description of means and measures to protect people 3. Procedure for arranging medical support
Public awareness	1. Procedure for informing the population and local executive and administrative authorities on whose territory there is a production facility about forecast and current emergencies at a production facility 2. Procedure for revealing information contained in a safety declaration

Therefore, the actions of the customer (operator), upon completion of construction and before commissioning, in a simplified manner, without taking into account the possibility of the implementation of these actions in parallel, can be presented as a chart in Figure 4.6.

Figure 4.6. Actions prior to commissioning and after completion of construction



The licensing state agency monitors compliance of licence applicants with licence requirements and conditions. Monitoring compliance with such requirements shall be in accordance with the acts for supervision activities. Gospromnadzor, in its supervisory activities in trunk pipeline transport, is governed by the following basic regulatory documents [148, 149, 150], which describe the legal basis of activity of this supervisory authority, the rights and duties of inspectors, etc.

According to [150], the supervisory authority shall have the right to appoint scheduled inspections for monitored entities with a high-risk group, no more than once in a calendar year. In the industrial safety category, the operation of hazardous production facilities, including pipelines, falls into a high-risk group. Under certain conditions, there can be an unscheduled inspection.

Article 46 of the Constitution of the Republic of Belarus [7] guarantees every citizen the right to a healthy environment. In this regard, it is worth noting that in the Republic of Belarus there is a continuous environmental monitoring at various stages of the life cycle of trunk pipelines, as well as other industrial facilities: during the development of project design documentation and the organization of construction and operation, which is reflected in the legal and technical legal regulatory acts.

The predesign (investments feasibility study in construction) and project design documentation, in accordance with the regulatory document [113], must necessarily include an "Environmental Protection" section. This section includes, as a rule, the following main topics:

- Air pollution protection
- Protection of surface and groundwater from pollution and depletion
- Protection and rational use of land resources
- Vegetation protection
- Wildlife protection
- Environmental protection from pollution by industrial waste, municipal and solid household waste

The amount of material presented in the "Environment Protection" section should be sufficient to determine the level of environmental hazards and the environmental impact of a facility under construction, including the effects due to disturbed ecosystems.

Such environmental protection measures should account for the best solutions of all alternatives.

In addition to an "Environmental Protection" section, according to [151], during development of project design documentation at the first stage to completion of design works, there should be an environmental impact assessment.

Environmental impact assessment includes a detailed evaluation of the current state of the environment and the forecast for possible changes with respect to those components and elements of the environment that may have a significant impact as a result of the planned activity. The environmental impact assessment shall evaluate:

- Climate and weather conditions
- Ambient air
- Surface water

- Geological environment and groundwater
- Topography, land resources and soil cover
- Flora and fauna

The analysis evaluates the environmental changes, makes the forecast of occurrence and impact assessment of potential accidents, and defines measures to prevent and minimize the adverse impact of a planned activity, etc.

During facility construction, it is also necessary to carry out activities and works on environmental protection, as indicated in the main document on the organization of construction production [128]. These activities should be described in the project design documentation: construction management project and works performance plan.

Activities and works on environmental protection should include land rehabilitation, prevention of loss of natural resources, prevention or treatment of hazardous discharge into soil, water bodies and the atmosphere. On the territory under construction, cutting down trees and shrubs is not allowed unless specified by project design documentation. Temporary roads and other access roads shall be constructed to meet the requirements for the prevention of damage to farmland and trees and shrubs. Industrial and household wastewater produced at the construction site, must be treated and disinfected.

During commissioning, the environmental aspect in the activities of trunk pipelines operators has a significant impact. For example, main pipelines facilities are regulated by a number of drafted documents on environmental protection [152, 153].

An operating facility must have an environmental passport, whose basic requirements for content are specified in [154]. The environmental passport covers overall use of natural and secondary material resources, monitoring of compliance with environmental protection requirements, and measuring the production impact on the environment. The environmental passport comprises the following elements:

- General information about the natural resources user
- Production characteristics of the natural resource user
- Ambient air protection
- Land resources use
- Water consumption and disposal
- Industrial waste treatment
- Information on corporate vehicles
- Measures for the rational use of natural resources and environmental protection
- Programme of implementation of the production control and local monitoring in environmental protection
- Cartographic material

Implementation of the environmental aspect accounts for a transboundary context involving water bodies, and is reflected in recommendations No. 22 and 27 of the Guidelines. The Republic of Belarus, according to [155], acceded to the Convention on the Protection and Use of Watercourses and International Lakes. Also, the Republic

of Belarus, under [156], adopted the Convention on Environmental Impact Assessment in a transboundary context [157]. Under this Convention, the Parties, individually or jointly, take all appropriate and effective measures to prevent significant adverse transboundary environmental impact from proposed activities, as well as reduce and control those impacts.

The Party of origin shall ensure that the environmental impact assessment is carried out before the decision on the implementation of planned activities, which may have a significant adverse transboundary impact. In Belarus, this aspect is covered by the Law [102].

There is an ongoing cooperation regarding transboundary impacts with the neighbouring countries (Russia, Ukraine, Latvia, Lithuania), which is fixed by bilateral regulatory legal acts [158, 159, 160, 161, 162]. Transboundary context aspects are also included in national legislation acts [12, 163].

Organizations operating pipelines are also cooperating in transboundary transfer issues. Within the framework of such cooperation, national operators of neighbouring countries may sign agreements on mutual assistance in emergencies, affecting transboundary water bodies.

National operators also have signed agreements on mutual assistance, in case of emergencies and insufficient technical means to eliminate the effects of accidents. Other organizations, such as railway operators, etc., may become parties to such agreements.

The aspect of the development of emergency external plans, contained in recommendation No. 25, 26, 28 of the Guidelines, is reflected in the regulatory legal act [164].

As early preventive measures for emergencies, the plans to protect the population and territories from natural and manmade emergencies should be developed in the Republic of Belarus, the same applies to the plans to protect the population and territories from natural and manmade emergencies, as developed by the executive and administrative bodies of the regions, districts and cities.

The plans for protection of the population and territories from natural and manmade emergencies, as well as prevention and emergency response plans are drafted by the Ministry of Emergency Situations; the scope and content of the measures in these plans are determined based on the principles of reasonable sufficiency and maximum possible use of available forces and means.

The aspect of Recommendations No. 29, 30, 31 of the Guidelines on the development of policies preventing interference by third parties is considered in the regulatory legal acts [165, 58].

According to [58], for normal operating conditions and prevention of damage to the main pipelines and their facilities, there must be buffer zones around them – 50 m along the pipeline axis on each side (100 m for underwater crossings).

As indicated in [165], before starting works, legal entities and individuals working in the buffer zone must obtain permission from the pipeline transport operator for such works. Persons who have been authorized to work in the protected zone of the main pipeline prior to the start of works must call in a representative of the pipeline transport operator to establish, based on the technical documentation, the exact location of the pipeline.

Before starting works in the buffer zone, an individual or organization carrying out the works must develop and agree with the pipeline transportation operator a works performance plan, which should include activities to ensure safe operations and safety of the existing pipeline and its facilities.

Excavations in the area, limited by a distance of 2 metres on either side of the pipeline, should only be carried out manually in the presence of the pipeline operator.

When local executives and administrative authorities review applications for land plots in the pipeline area, construction locations must first be agreed with pipeline transport companies.

Aspects of Recommendations No. 30 and 31 of the Guidelines for the exchange of information are reflected in many acts at different stages of the main pipeline life cycle. The most significant acts are [16, 147, 165, 58].

During identification and declaration process, the pipeline organization general manager submits a list of the facilities and a safety declaration to the headquarters of Civil Defense, Emergency Commission, Gospromnadzor, higher-rank organizations, and local executive and administrative authorities, where the production facility is located, etc. [147].

Materials containing information on the actual location of pipelines and technological communication cables are transferred by pipeline transport enterprises to the relevant local executive and administrative bodies to be put on regional land-use maps.

Pipeline transportation companies provide information on the location of pipes and technological communication cables to interested companies, organizations and institutions, following their requests.

Legal and natural persons, authorized to work in the pipeline buffer zone by the pipeline transport operator should be informed about the existence or possible occurrence and nature of hazardous production factors.

In areas of main pipelines, pursuant to [58], for third party information there are identification poles with information plates along a pipeline axis:

- On straight sections of a route within the visibility range, but at least as frequently as 500 metres
- At pipeline turning points

- At the intersection with other above-ground and underground utilities
- In places of crossing navigable and non-navigable obstructions, ravines, and canals
- In places of repair works
- To indicate places of trench works, washouts, and pipeline surfacing

An information plate must indicate:

- The pipeline buffer zone dimension
- A character's marking (kilometre, ranging point) to the pipeline route
- Phone numbers and addresses of operation control and emergency services of a production unit

Recommendations for the application of the Guidelines and Good Practices to ensure pipeline operational reliability

The Guidelines under review contain general requirements and recommendations without specific quantitative features, and its content is close to regulatory legal acts of the same hierarchical level as laws and to technical regulatory legal acts of the same level as technical regulations.

The comparative analysis of the Guidelines with the regulatory and regulatory-technical basis of the Republic of Belarus in the main pipeline transport shows that most of the paragraphs of this document are contained in the provisions of the Belarusian acts, often complementing and extending its requirements and recommendations. Overall, the provisions of the Guidelines (the role of the competent authorities, the responsibility of the operator, the requirements at different stages of life cycle, etc.) with regard to their content are similar to the provisions of the Law of the Republic of Belarus "On Main Pipeline Transport" [2] and the Law of the Republic of Belarus "On Industrial Safety of Hazardous Production Facilities" [16]. These laws are among the most fundamental laws that govern the production activity in the main pipeline transport in the Republic of Belarus.

At the same time, one can assume that there are paragraphs in the Guidelines that are currently important and appropriate to recommend for use to organize work of the Belarusian trunk pipelines operators. Analysis of the content of these paragraphs of the Guidelines resulted in drafting four recommendations to be presented for the review of the participants of the workshop under the name of "Environmental safety of gas and oil pipelines in Belarus". The workshop participants discussed these Recommendations and introduced a number of proposals to be extended and amended followed by their adoption of a final version and becoming the main results of the workshop.

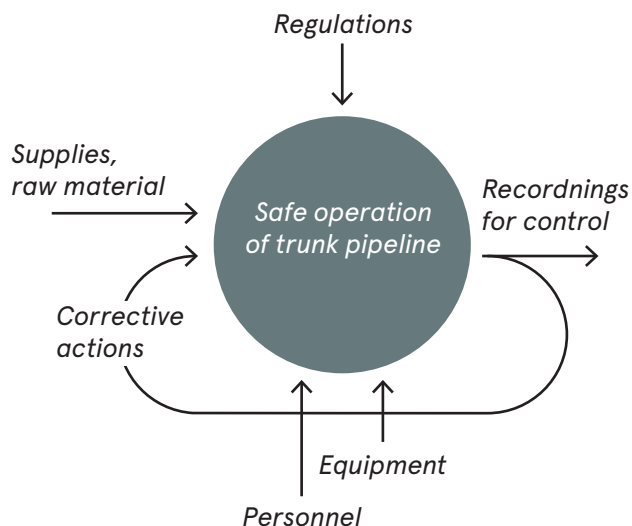
Recommendation 1. *"We recommend updating technical regulatory legal acts (technical regulations) of Belarus in pipeline transport in line with the legal and regulatory framework that is being created in the Customs Union and in view of best practices of the EU countries."*

In this regard, the important paragraph of the Guidelines, underpinning this recommendation, is principle No 9 stating that the construction and operation of pipelines should foresee and prevent any emergencies.

This principle is complex by nature because pipeline safety, including the environmental aspects, is based on the entire system of its constituent elements, each of which consists of a number of elements of lower order and affecting factors.

Those elements responsible for pipeline safety include: qualified personnel, team spirit, a favourable working environment, state-of-the-art equipment and technology, sufficient funding, process control and corrective actions, high-quality raw materials and supplies, etc. A model of safe operation of a trunk pipeline transport company with its constituent elements in a simplified form at the upper level of notations in IDEF0 is shown in Figure 5.1.

Figure 5.1. Model of activity of a trunk pipeline company



Among the elements that affect trunk pipeline safety, essentially important are regulatory documents: legal regulatory acts, technical regulatory legal acts, and in-house corporate documents (directives, orders, plans, etc.). The information contained in the acts is a basis for the company's activities, as these acts are binding and include numerous safety issues, technical support, requirements for personnel, i.e., regulations provide a model of corporate activities. For this reason, the information found in the regulations is vitally important for ensuring the safety and reliability of the main pipeline transport. Proper regulatory acts containing pro-

fessionally developed requirements can significantly reduce accidents at the main pipelines.

At the same time, operating experience of pipeline operators regarding past accidents (incidents, violations), as well as innovative technologies and new organizational approaches, in its turn, may have an impact on the growing need for the development of new versions of regulations. Outdated requirements for personnel, equipment, etc., may hinder technical development of a company or increase costs in operating obsolete equipment. New regulations may incorporate timely and necessary changes that update regulations and take into account the interests and needs of the operator, government agencies and the public.

In this context, based on paragraph No. 9 of the Guidelines, one should point out a very significant recommendation to consider updating technical regulatory legal acts for the main pipeline transport.

As part of this recommendation, there is a need for holding discussions with main pipeline transport operators to establish which regulations must be fully revised due to their long-term application and obsolescence or partially revised and updated with the advent of new technologies; as well as which regulations are missing and need to be developed.

The main pipeline transport domain has a few documents that require partial or full revision. For example, the validity of the underpinning trunk pipeline transport regulations is more than or about 10 years. These acts include SNIP (construction norms and regulations) 2.05.06 "Main Pipelines" [17], SNIP III-42-80 "Rules of performance and acceptance of works. Main Pipelines" [36] "Rules of protection of main pipelines" [58] "Instructions for performance of works in pipelines buffer zones" [165], the Law of the Republic of Belarus "On Main Pipeline Transport" [2], and the Law of the Republic of Belarus "On Industrial safety of hazardous production facilities" [16]. Therefore, there is an objective need for updating and revising these documents. Currently, public authorities and operators are discussing the issues of revision of these acts; and the Law "On Industrial Safety of Hazardous Production Facilities" [16] has a new draft version. It is advisable to apply or take into consideration the provisions of the Guidelines when developing these documents.

Among the documents that have to be developed, one can identify the most important document in ensuring pipeline safety, i.e., Technical Regulations. The reform of technical regulation and standardization, initiated in 2004 with the adoption of the Law of the Republic of Belarus "On Technical Regulation and Standardization" [11], aimed at harmonizing the approaches of the national technical regulation with the international practices, in particular with those applied in the European Union, has resulted in creation of new kinds of technical regulatory legal acts. The most important among them is the Technical Regulations governing safety of operations and is an

analogue of the EU Directive. Following the formation of the Customs Union in 2010, which included the Republic of Belarus, the Russian Federation, and Kazakhstan, the Technical Regulations are being developed jointly by the three countries, taking into account the national interests of each. This document has the status of the Technical Regulations of the Customs Union.

Currently the member states of the Customs Union are developing the Technical Regulations in main pipeline transport safety. During this work, there were a few meetings of the working groups, which discussed proposals and comments introduced into the technical regulatory legal act. The next stage of the work with this document is a public hearing.

Given that the Technical Regulations, as well as the Guidelines, for the most part would contain general requirements on safety of main pipelines, and that the requirements of the Guidelines draw on international practices, we can recommend the use of approaches of the Guidelines for developing Technical Regulations of the Customs Union at the stage of its public hearing.

The fact that some of the national operators of the main pipeline transport became the property of the Russian joint-stock companies has led to a change of approach in the use of technical regulatory legal acts by these operators. Currently, in the course of their operations, they not only use Belarusian technical regulatory legal acts but also those of the Russian corporate owners. Such acts are owned by the Russian companies and often intended for internal use only.

In this case, the operators of the facilities of trunk pipeline transportation may not be aware of the system of technical regulations of each of them. This leads to a situation when one operator is developing a technical act for a certain process as a company standard, another operator as a Technical Code, and a third operator simply does not have it. Therefore, it is extremely important to introduce exchange of information among operators with regard to technical regulations effective in their companies. Consequently, this practice will create a unified database of names of technical regulations of national operators of pipeline transport. A common information base of the names of technical acts will make it possible to increase the awareness and skills of specialists at these enterprises, join forces in developing the necessary technical acts, accelerate the process of harmonization of technical regulations of the Russian holding companies with the national technical regulations, and identify priority processes that require the development of technical regulations.

Regarding updating of the technical regulations, one should pay attention to such important paragraphs of the Annexes of the Guidelines as "Design and Construction" and "Construction and Testing", which contain important provisions on engineering design, materials, instruments, controls, protection against corrosion, fire and explosions, equipment, etc. These provisions must be taken

into account during the revision of technical regulations in this field. It is necessary to identify not only the acts that require revision, but also to discuss the engineering content of these acts, and identify:

- Outdated technologies, equipment, organizational approaches, materials, construction methods, and operational requirements
- Up-to-date technologies, innovations, modern materials and equipment, improved organizational approaches, and choose the best to be included in the new technical regulatory legal acts

Being interdependent and having a common content, Recommendation 1 and Recommendation 2 are considered together.

Recommendation 2. "We recommend stepping up the work of the Belarusian National Technical Committee for Standardization "Main pipeline transport of oil, gas and petroleum products" (TK 17).

This Recommendation is founded on provision No. 25 of the Guidelines regarding the necessity to assign competent bodies in charge of assignments specified within their authority.

As part of the recommendations on the updating of the regulations, it is necessary to consider methods to enhance the activity of TK17 and develop mechanisms to properly support this structural unit. The National Technical Committee for Standardization in main pipeline transport, which was created for the purpose of revising technical acts, has done significant work so far, however, the results of technical acts revision by this Committee may be considered inadequate.

This issue can be best solved by the joint discussions of TK17, main pipeline operators and Gospromnadzor, which will allow for proposals from all parties and taking next steps in the organization of TK17 activities. For example, there can be a proposal for the development of a system of technical regulatory legal acts in the main pipeline transport, whose creation can make it possible to extensively evaluate the existing set of regulatory documents, compare the current acts on the main oil pipelines, gas pipelines, product pipelines and identify missing elements (technical regulatory legal acts).

Referring to Recommendation No. 25 of the Guidelines regarding the need to appoint competent authorities in different areas, it should be noted that at the present time in the Republic of Belarus there is no competent body that is part of the public standardization authorities with powers in the development, coordination, and approval of technical regulatory legal acts in main pipeline transport. The absence of a single government body that coordinates the development and finally approves technical regulatory legal acts as a competent authority is one of the main reasons for slow development and approval of a number of new technical regulations in the main pipeline transport.

This issue is partially resolved at the level of development of national standards that are approved by the State Standard. TK17, in the interests of main pipeline transport operators, can make a list of technical acts that need to be updated or developed and submit it to the standardization plan for the coming year.

With regard to technical codes of current practice, which traditionally contain requirements related to processes, this approach does not work for the simple reason that such acts are departmental and must be approved by the relevant ministries. At the moment, some of the Belarusian main pipeline transport enterprises are under the jurisdiction of Russian joint-stock companies. In this regard, the creation of a single body to coordinate the development of technical regulatory legal acts is a very urgent task.

The workshop jointly discussed Recommendations 1 and 2 and developed the following additions:

- a) To initiate setting up a single competent body authorized to approve technical regulations in the field of main pipeline transport, whose absence is one of the reasons for the slow development and approval of new technical legal and regulatory acts
- b) To improve the work of Technical Committee (TK17) in all areas which requires creating a favourable environment for its activities' implementation
- c) To start drafting a national system of technical regulatory and legal acts for main pipeline transport in Belarus

- d) To make a list of technical regulations that need to be developed, updated or brought in line with the regulatory framework of the Customs Union
- e) To implement a daily practice of information exchange among operators regarding their current technical regulations, and to create a unified database containing the names of technical legal and regulatory acts of the national pipeline transport operators
- f) To update SNIP 02-05-06-85 and SNIP III 42-80 complying with current approaches, technologies and requirements for technical legal and regulatory acts.

Recommendation 3. "We recommend enhancing the coordination of planning and actions in the event of an emergency on main pipelines through development and implementation of relevant technical regulations."

Another paragraph of the Guidelines that must be accounted for in the process of organization of the operation of main pipeline transport in the Republic of Belarus, is the paragraph of the Annex "Planning for emergencies". This paragraph includes the description of the content of contingency plans in the event of external and internal emergencies.

The Law [2] on emergency planning contains general provisions. For instance, Article 16 "Ensuring Safety of Construction of Main Pipelines" specifies that one of the requirements for the construction of trunk pipelines is to compile a list of possible emergencies and develop an action plan



for prevention and mitigation of the consequences. Article 17 "Ensuring Safety of Operation of Main Pipelines" states that one of the responsibilities of the operator, in order to ensure industrial, fire and environmental safety, is to develop measures for the prevention, containment and clean-up of possible incidents and accidents, as well as the preparation of contingency action plans.

The Law [16] also contains general provisions on the plans for localization and clean-up of potential accidents. For instance, Article 10 "Industrial safety requirements for design, construction and acceptance" states that in the process of commissioning hazardous production facilities, one should check the readiness of hazardous production facilities for actions to locate and eliminate the consequences of accidents. Article 15 "Industrial safety requirements regarding preparedness for localization and clean-up of the consequences of accidents at the hazardous production facility" specifies that organizations are obliged to plan and implement measures to contain and eliminate the consequences of accidents at hazardous production facilities.

On reviewing the provisions of the Belarusian law, it becomes clear that these legal acts do not contain detailed information on drawing up plans for localization and clean-up of emergencies. At present, the instructions found in the regulatory documents are scattered locally, and may have been developed by each institution, for example [30]. Also, the instructions may have been drafted for a separate activity, for example, Decree No. 23 of the Ministry of Emergency Situations of the Republic of Belarus as of 05.08.2004 "On approval of the Standard instruction regarding actions of workers in emergencies at ammonia-refrigeration plants, chlorine warehouses and chlorination units" [101], or developed as a company standard.

Therefore, as another recommendation, it is necessary, based on the Guidelines, in the regulations of the Republic of Belarus for main pipeline transport operators to specify contents of plans for localization and clean-up of emergencies or to develop a unified regulatory act for all operators, such as an instruction, a provision or rules for drafting these plans.

Following discussions in the groups, the workshop participants developed the following additions with regard to Recommendation 3:

- a) *It is necessary to draft a single regulatory act containing a sample plan of clean-up of emergencies for main pipeline transport facilities for all operators*
- b) *Technical regulations require a full and detailed description of public information issues concerning the presence, state, potential threats and emergencies at hazardous production facilities*

Recommendation 4. "We recommend upgrading methodological approaches to risk and hazard assessment in emergency on pipeline transport facilities."

Other paragraphs of the Guidelines, which may prove useful to organize the activities of operators and develop regulations are principle No. 12 and the paragraph within the Annex called "Assessment of hazard/risk and land-use planning." In this section, there are different kinds of approaches and methods for the evaluation of hazard/risk assessment: deterministic and probabilistic approaches, qualitative and quantitative methods.

Article 16 of the Law [2] provides information that for pipeline construction one of the requirements is the availability of a declaration of industrial safety. Article 11 "Industrial safety requirements for operation of hazardous production facility" of the Law [16] states that the operator must develop a declaration of industrial safety. Article 19 "Development of Industrial Safety Declaration" points out that the development of industrial safety declaration must be accompanied by a comprehensive assessment of risks of accidents and related threats. The list of data in the declaration of industrial safety and its filing procedures are to be determined by central governmental authorities in industrial safety. The Law [16] was supplemented by a regulatory act called "Procedure for drafting declaration of hazardous production facilities" [147] which comprises the basic provisions regarding the content of safety declaration and its development. Nevertheless, the provisions of these regulatory acts call for risk assessment by trunk pipeline operators, but do not reveal approaches to risk assessment, its methods and calculation examples.

Therefore, it is considered appropriate, based on the experience of development of the Guidelines, to amend the regulations or create a separate regulatory act for linear and on-site sections of main pipelines with a detailed description of existing approaches and risk assessment methods with detailed case studies.

Following the discussions of Recommendation 4, the additions listed below were adopted:

- a) *It is necessary to develop a geographic information system (GIS), which takes into account internal factors that determine conditions of a pipeline (design solutions, current technical state, type of maintenance, etc.) and external factors that determine the conditions of escalation or de-escalation of accidents (landscape features, geo-seismic impact, vegetation - including rare species of plants, hydrological situation, and others)*
- b) *It is necessary to draft a technical regulation, which shall contain methodology of hazards analysis and risk assessment with regard to a potential accident at a main pipeline linear part*

Annex 1

The content of the articles of the Law of the Republic of Belarus "On Main Pipeline Transport" (from Table 1.1)

Article 6. Main principles of activity in main pipeline transport

The main principles of activities in the trunk pipeline transport are:

- Priorities of safety of citizens and the state, environmental protection
- Interests of all parties involved in main pipeline transport
- Use of state-of-the-art technologies in construction and operation of main pipelines
- Mandatory state regulation of activities in main pipeline transport and creation of favourable economic and other conditions for the operation and development of main pipeline transport
- Transparency of investment policies and pricing of services of transporting products through main pipelines
- Inadmissibility of arbitrary interference by citizens and organizations in the economic and production activities of owners and operators of main pipelines or main pipeline networks
- Compulsory full compensation for the harm caused to the environment, life and health of citizens, their property, and property of organizations during construction, operation and liquidation of trunk pipelines and their facilities

Article 8. The main powers of local councils of deputies, local executives and administrative authorities in main pipeline transport

The main powers of local councils of deputies, local executive and administrative authorities in the field of main pipeline transport include:

- Participation in realization of state policy in the field of main pipeline transport
- Making available for use isolated water bodies to main pipeline owners under the established procedure
- Participation in commissioning of main pipelines and/or their facilities and acceptance of land plots after liquidation of main pipelines and/or its facilities
- Assistance in the clean-up of accidents and transportation of goods to the site of accidents
- Other powers in accordance with the legislation of the Republic of Belarus

Article 9. Interaction of the owners and operators of trunk pipelines with local executives and administrative authorities

The owners and operators of main pipelines interact with the local executive and administrative authorities during the construction, operation, preservation and liquidation of main pipelines regarding safety issues, as well as when addressing the issues of socioeconomic development of territories with main pipelines routes and other matters, as provided for in this Law.

Article 10. State regulation in the field of main pipeline transport

State regulation in the field of main pipeline transport is performed by the President of the Republic of Belarus, the Council of Ministers of the Republic of Belarus, and authorized state agencies in accordance with the legislation of the Republic of Belarus.

State regulation in the field of main pipeline transport includes:

- Development and implementation of state policy in main pipeline transport
- Development, approval and facilitation of the implementation of state programmes for main pipeline transport development
- Control (supervision) in main pipeline transport
- Licensing activities in industrial safety (works and services for design, installation of facilities of trunk gas pipelines, trunk oil pipelines, oil product pipelines), as well as technical regulatory legal regulation, standardization, ensuring compliance with requirements of technical legal acts in technical regulation and standardization and ensuring the uniformity of measurements in main pipeline transport
- Establishment of the procedure for rendering services for transportation of products through main pipelines
- Making requirements for ensuring industrial, fire and environmental safety during construction, operation, preservation and liquidation of main pipelines and their facilities
- Pricing policy for services on transportation of products
- Defining emergency response in case of accidents on main pipelines
- Establishing procedures for the provision of information on industrial, fire and environmental safety of main pipelines
- Organization of international cooperation in main pipeline transport
- Other forms and methods of state regulation

Article 11. State management in the field of main pipeline transport

State management in the field of main pipeline transport is performed by the Council of Ministers of the Republic of Belarus. The Council of Ministers of the Republic of Belarus shall:

- Define the principal direction of state policy in main pipeline transport
- Set the priorities for main pipeline transport development
- Organize the development and ensure the implementation of state programmes in main pipeline transport
- Choose the direction of international cooperation of the Republic of Belarus in main pipeline transport
- Resolve other issues in main pipeline transport in accordance with the laws of the Republic of Belarus

The Council of Ministers shall exercise its powers in main pipeline transport directly or through authorized state agencies and other state legal entities.

Article 13. Technical regulation, standardization and assessment of compliance with requirements of technical regulatory legal acts in technical regulation and standardization

In order to ensure safety of life and health of citizens, property and environment protection, the main pipeline transport is governed by technical regulation, standardization and assessment of compliance with requirements of technical regulatory legal acts in technical regulation and standardization.

Technical regulatory legal acts in technical regulation and standardization, establishing requirements for the safe operation of main pipelines, must take into account the features of the environment and contain conditions that exclude the possibility of accidents and ensure sufficient safety of design and technological solutions.

The application of international standards in the construction and operation of transboundary trunk pipelines on territory of the Republic of Belarus is allowed, if the specifications are not contrary to the laws of the Republic of Belarus and these standards are duly adopted on the territory of the Republic of Belarus as the state standards of the Republic of Belarus.

Technological equipment used in construction, operation, preservation and liquidation of main pipelines, and transportation services through main pipelines are subject to mandatory assessment of compliance with technical regulatory legal acts in technical regulation and standardization, in cases and under procedure set forth by the legislation of the Republic of Belarus.

Prototype models of technological equipment used in construction and operation of main pipelines are tested to assess their level of industrial, fire and environmental safety.

Article 15. Control (supervision) in main pipeline transport

Control (supervision) in main pipeline transport is carried out in accordance with the legislation of the Republic of Belarus on monitoring (supervisory) activities.

Article 16. Safety in main pipelines construction

Construction of trunk pipelines has to comply with the requirements on industrial, fire and environmental safety of main pipelines, established by this Law and other laws of the Republic of Belarus, and includes:

- Making an industrial safety declaration and environmental passport of main pipelines
- Environmental impact assessment of the planned activity on construction and operation of main pipelines
- Route selection, taking into account natural features of the area, location of settlements, soil corrosiveness, peat bogs bedding, as well as transport routes and communications that can have a negative impact on the main pipeline
- Use of technological equipment, which has been found adequate in terms of requirements of technical regulatory legal acts in the field of technical regulation and standardization, given its suitability to operating conditions
- Implementation of measures for pipeline corrosion protection
- Development of measures to ensure industrial, fire and environmental safety, preservation of protected natural reserves and natural areas that are subject to special protection, biosphere reserves and other areas that are subject to special protection and use, and other measures for environmental protection, protection of historical and cultural values, industrial and environmental monitoring
- Drafting a list of potential emergencies, an action plan for the prevention and clean-up of effects of accidents

The procedure for development, coordination and approval of the declaration of industrial safety and environmental passports of trunk pipelines is determined by the laws of the Republic of Belarus.

Main pipeline route selection and most suitable placement options of its facilities are made based on the solutions of duly approved urban development projects and national ecological network chart, taking into account the results of environmental impact assessment of planned technological solutions, authorized natural resources use limits and evaluation of damage to the environment and population, residing in the area of main pipeline location.

Construction of main pipelines in residential areas, nature reserves, protected areas of national parks, zones of sanitary protection of drinking water sources, as well as in dangerous geological conditions that threaten safety during all types of construction and maintenance works is prohibited unless justified by environmental research and environment impact assessment.

Design technical solutions for main pipeline construction must comply with the required level of reliability of their facilities for a fixed operational period and cause minimum damage to the environment, in case of failure of pipelines and other main pipeline facilities.

In order to reduce the negative impact on water bodies from main pipelines, trenchless technologies and other modern technical solutions that ensure environmental safety of water bodies and the navigation regime, as well as preservation of valuable commercial species of fish, aquatic plants and animals should be applied.

If it is impossible to implement environmental protection measures in full by pre-design and project design documentation for construction of main pipelines, one must take compensation actions to offset the damage to the environment in accordance with the legislation of the Republic of Belarus.

Project design documentation on underwater main pipelines provides for compensatory measures to ensure the preservation of valuable commercial species of fish, aquatic plants and animals.

The conclusions of environmental impact assessments of design solutions for construction and operation of main pipelines, a draft industrial safety declaration, as well as project design documentation for main pipeline construction are submitted for approval by the authorized state agencies and sent to the state examination office according to the procedure prescribed by the laws of the Republic of Belarus.

Amendments to design solutions on the location of main pipeline facilities and technology solutions entail additional approval, with regard to these changes, by government authorities and repeated state examinations in accordance with the legislation of the Republic of Belarus.

Project design documentation for construction of a main pipeline or its facilities, subject to state examination, in accordance with the legislation of the Republic of Belarus, which failed to receive positive conclusions of this review shall not be implemented unless otherwise established by the President of the Republic of Belarus.

The main pipeline owner bears the costs for conducting environmental impact assessments during the development of project design documentation and for environmental and other surveys related to justification of acceptability of design solutions and state examinations.

It is forbidden to commission main pipelines that are not equipped with monitoring tools to measure their industrial, fire, environmental and other safety, in accordance with the legislation of the Republic of Belarus.

Article 17. Ensuring safety in pipeline operation

Economic agents in the field of main pipeline transport operation must comply with the requirements of indus-

trial, fire and environmental safety established by the legislation of the Republic of Belarus.

In order to ensure industrial, fire and environmental safety, the operator must:

- Diagnose the technical condition of main pipeline facilities, measuring devices and equipment, as well as conduct technical re-examination of main pipeline facilities after depreciation useful life, in case of inability to ensure their safety and security
- Comply with the legislation of the Republic of Belarus on environmental protection and carry out fire-prevention works on main pipeline facilities
- Monitor fire, industrial and environmental safety of main pipelines
- Develop measures for the prevention, containment and clean-up of possible incidents, accidents, as well as contingency plans for emergencies
- Train main pipeline personnel to act in emergencies
- Create a system of detection and warning for incidents, accidents and emergencies, keep this system on standby
- In timely fashion, develop and approve with the Ministry of Natural Resources and Environmental Protection of Belarus specifications of emissions (discharges) of pollutants into the environment, location and volume of waste generated during main pipeline facilities operation
- Maintain buffer pipeline zones to ensure their industrial safety and protection of the population in the designed operation mode and in emergencies
- Create reserves of financial and material resources for the prevention of emergencies and clean-up of their consequences, as well as special task units for the protection of main pipeline facilities, emergency and rescue services for emergency response, in accordance with the laws of the Republic of Belarus
- Fulfill other requirements in accordance with the legislation of the Republic of Belarus

The operator is obliged to carry out prompt and effective actions to address the consequences of incidents and accidents that have resulted in malfunction of the main pipelines and their facilities, in order to prevent damage to the life and health of citizens, their property, the environment, and corporate property.

Article 20. Planning of main pipeline construction

Planning of pipeline construction should be accompanied by a feasibility study of proposed solutions and an environmental assessment for their implementation, including funding and a list of measures to protect the environment, as well as a list of measures to protect the social and economic interests of the people on the territories where pipeline construction is being planned, and based on the solutions of duly approved urban development projects and schemes of the national ecological network.

Planning for main pipeline transport development is made in view of the complex development of the Republic of Belarus on the basis of the plans and programmes of the

Republic of Belarus, including the country's defence potential, in accordance with the legislation of the Republic of Belarus.

Article 24. Management of main pipelines or main pipeline system

Management of main pipelines or main pipeline systems includes economic, financial and organizational management, as well as activities to ensure efficient, reliable and safe operation of main pipeline facilities and product transportation through main pipelines, which is carried out by the operator.

The operator provides main pipelines operation from its own funds and/or funds from other sources, as well as the delivery of products to the customer under contractual terms for the provision of product transportation through main pipelines.

When connecting a main pipeline to the existing main pipeline or existing system of main pipelines, the management of the connected pipeline is carried out in accordance with the terms of the contract between the operator of the existing main pipeline or existing system of main pipelines and the operator of the connected pipeline or their authorized persons.

To ensure safe operation of main pipelines, the operator is obliged, based on the monitoring results of the technical condition, in a timely manner to carry out overhaul and regular repair of trunk pipelines facilities, eliminate incidents, accidents and emergencies on the main pipelines, as well as their effects.

The operator has the right to decommission main pipelines prior to previously guaranteed terms of industrial safety or before any overhaul period without consent of the owner of the main pipeline or main pipeline system in the event of an accident, as well as based on monitoring results indicating technical conditions that can result in an accident or incident.

Article 25. Interaction of organizations in main pipeline operation

In case of the construction of other utilities owned, used or controlled by other organizations in the main pipeline buffer zone, as well as in the case of their intersection, contracts between main pipeline operators and operators of other communications should include commitments for their joint action to ensure safety of the main pipeline and communications, as well as actions to prevent and eliminate incidents, accidents, emergencies and their effects.

Repair and recovery and other urgent works on main pipelines at their intersection or proximity with other communications are permitted only after notification of the owners of these communications.

If the existing pipeline should be crossed by newly created pipelines, roads and railways, or other utilities, the costs associated with the refurbishment of the existing pipelines are covered by the owner of the newly constructed communications.

If existing utilities should be crossed by newly constructed main pipelines, the costs associated with the disruption of existing utility operations are covered by the owner of the newly constructed main pipelines.

Article 30. Protection of main pipelines

Protection of main pipelines and their facilities is carried out by the operator and organizations having, in accordance with the legislation of the Republic of Belarus, the right to carry out such activities.

In case of emergency or martial law, the protection of certain particularly important and sensitive sites of main pipelines, the list of which is determined by the Council of Ministers, is done in accordance with the state of emergency and martial law.

Article 31. Organization of works in case of incidents, accidents and emergencies on main pipelines

The operator, in case of incidents, accidents and emergencies on the main pipelines, duly informs the local executive and administrative authorities and other government agencies, in accordance with the laws of the Republic of Belarus, and takes prompt measures to eliminate their consequences. For this purpose, the operator can use land adjacent to the pipeline, in accordance with the legislation of the Republic of Belarus.

Participation of central government agencies, local executive and administrative authorities and organizations in the clean-up of incidents, accidents and emergencies and their consequences on the main pipelines is carried out in accordance with the legislation of the Republic of Belarus.

For a period of force majeure and clean-up of its consequences, fulfillment of the contractual obligations for transporting products through main pipelines is performed in accordance with the Civil Code of the Republic of Belarus.

Article 32. Financial support of pipeline safety

Funding for localization and mitigation of accidents and emergencies that arise as a result of accidents on the main pipeline is the responsibility of the operator.

The operator, under contingency plans for emergency prevention and clean-up, establishes a material and financial fund for the clean-up of accidents and emergencies, the amount of which is approved by the Ministry of Emergency Situations of the Republic of Belarus.

In case of insufficient funding by the operator for emergency response on the main pipeline, the legislation of the Republic of Belarus provides for the use of funds from other sources.

Article 36. Compensation for damage caused during construction, renovation, operation, preservation and liquidation of main pipelines

The owner and/or operator of main pipelines or main pipeline systems must pay compensation for the damage caused to life and health of citizens, their property, the environment, and corporate property during construction, renovation, operation, preservation and liquidation of main pipelines in full, unless it is proven that this damage was due to force majeure or intent of the victim. Such persons may be exempted by the court from liability for damage in full or in part only on the grounds provided by the Civil Code of the Republic of Belarus.

The obligation to compensate for damage caused during construction, renovation, operation, preservation and liquidation of main pipelines can be laid on another person by legislative acts.

Compensation for damage caused to the environment during construction, renovation, operation, preservation and liquidation of main pipelines shall take place in accordance with the laws of the Republic of Belarus.

The liabilities with regard to compensation for damage caused to life or health of citizens, their property and corporate property during construction, renovation, operation, preservation and liquidation of main pipelines are laid on the owner and/or the operator of main pipelines, in accordance with the laws of the Republic of Belarus.

Compensation of expenses related to works to prevent or minimize adverse impact on the environment and to eliminate emergencies caused by construction, renovation, operation, preservation and liquidation of main pipelines is made by those responsible for the damage, and in case of a natural disaster, in accordance with the legislation of the Republic of Belarus.

Annex 2

An example of calculating risk of accidents on linear section of main oil pipeline

The assessment of risk degree of accidents on a linear section of a pipeline is usually done with the method based on the combined use of the techniques [98] and [99].

This method makes it possible to determine specific risk of an accident, i.e., shows to what extent one section of a pipeline is more dangerous than others.

Specific risk of an accident for each section is determined:

$$R = \lambda_n \cdot p_{\partial\Pi} \quad (\text{P1.1})$$

where, λ_n – specific probability of an accident at a given section;

$p_{\partial\Pi}$ – coefficient of severity of consequences.

Accidents on an oil pipeline is characterized by the presence of considerable differences in the values of average frequency of accidents on oil pipeline $\bar{\lambda}$ and its separate

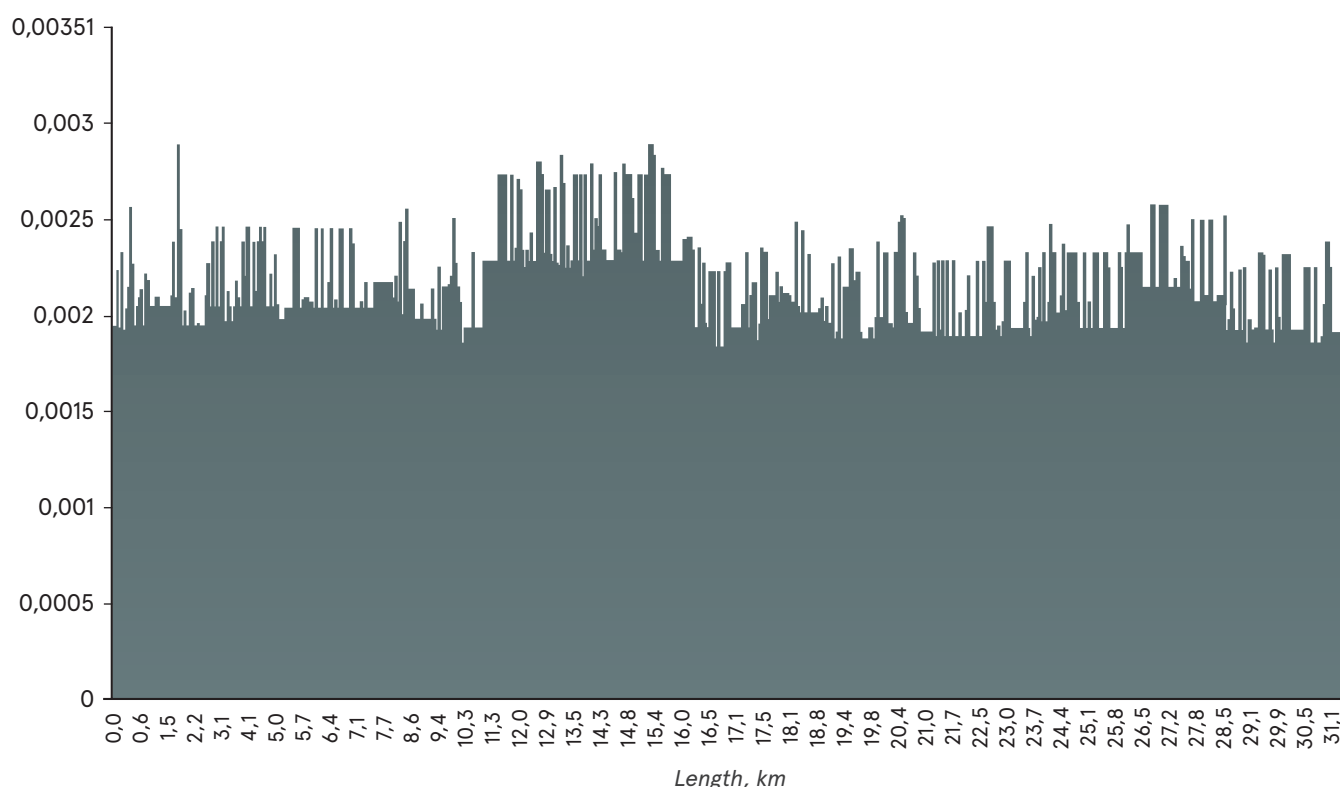
sections λ_n , which differ in their structural and technological characteristics, features of design, construction and different environmental conditions of operation and social environment. An example of calculating specific frequency of accidents is shown in *Figure A2.1*.

The mechanism of registering the distribution of accidents in the risk assessment is implemented using the procedure of dividing a route of the pipeline under review into sections, characterized by approximately constant value of the local frequency (specific intensity) of accidents within each section. The local frequency of emergency faults at each of these sections is determined on the basis of the finite set of factors that affect the reliability of a pipeline. Groups of factors that affect the state of a linear section of an oil pipeline are adopted in accordance with [98].

Relative contribution of factor $F_{i,j}$ inside its group into the change of intensity of emergency faults on the studied section of a pipeline is calculated with the help of weighting factor (of share) $q_{i,j}$.

Figure A1.1. Example of calculation results of specific frequency of accidents.

Probability (specific frequency) of accidents,
(accidents/year*km)



Depending on the set of specific values of the various affecting factors which occur on the studied section of an oil pipeline route, the intensity of emergency faults on it will be more or less different from the average for this route $\bar{\lambda}$.

Therefore, on each n section of a route we determine the value of cumulative coefficient $k_{\partial\pi}$, indicating by how many times the probability (specific frequency) of accidents on section λ_n differs from the average one for the given route $\bar{\lambda}$:

$$\lambda_n = \bar{\lambda} \cdot k_{\partial\pi} \quad (\text{P1.2})$$

Value λ is calculated based on the statistical data on accidents at the enterprise, operating the given oil pipeline according to the existing "Journal of accidents and incidents" which is available at all enterprises. The calculation is made by formula:

$$\bar{\lambda} = \frac{A}{T \cdot L} \quad (\text{P1.3})$$

where A – number of accidents on a given oil pipeline;
 T – operation period of an oil pipeline;
 L – length of an oil pipeline.

Influence of the factors of the above groups on oil pipelines is estimated by points system based on ten-point scale. The range of variation and the contribution of each factor into the generalized numerical score is determined by adding points of each factor using the "weighting factors".

Calculation of coefficient $k_{\partial\pi}$ is made with the help of points system when each factor $F_{i,j}$ is given correspondence of definite, assigned by calculation or expertise, the number of points $B_{i,j}$ (on ten-point scale), reflecting the intensity of its influence. When considering a certain i section of a route, we consequently estimate the intensity of influence of each factor. Obtained for all affecting factors, points $B_{i,j}$ are put into the following formulas to determine $k_{\partial\pi}$.

$$k_{\partial\pi} = \frac{F_n}{B^*} \quad (\text{P1.4})$$

$$\text{where } F_n = \sum_{i=1}^I \sum_{j=1}^{J(i)} p_{i,j} \cdot q_{i,j} \cdot B_{i,j}$$

– probability of fault in points;

p_i – weighting factor of groups of factors (under annex 2 [98]);

$q_{i,j}$ – weighting factor of factor $F_{i,j}$ (under annex 2 [98]);

$B_{i,j}$ – point of factor $F_{i,j}$;

I – number of groups of factors;

$J(i)$ – number of factors in i group.

B^* – average point.

$$B^* = \frac{1}{N} \sum_{n=1}^N F_n \quad (\text{P1.5})$$

Under annex 2 [98], values of coefficients p_i , $q_{i,j}$ и $B_{i,j}$ must be specified for a certain oil pipeline using the statistical data on faults and accidents and opinions of specialists of an operating company.

As an example, let us make calculation for a certain spot of a main oil pipeline based on the above methodology. Let us calculate specific risk of an accident for a section of a main pipeline:

$$R = \lambda_n \cdot p_{\partial\pi} \quad (\text{P1.6})$$

Specific probability of an accident is estimated as follows:

$$\lambda_n = \lambda \cdot k_{\partial\pi} \quad (\text{P1.7})$$

$$\text{where, } \bar{\lambda} = \frac{3}{45 \cdot 32} = 0,002083$$

– average probability of an accident (given for a certain oil pipeline).

where A – number of accidents at a given oil pipeline;

T – operation period of an oil pipeline;

L – length of an oil pipeline.

$k_{\partial\pi}$ – coefficient of influence.

Calculation of coefficient $k_{\partial\pi}$, according to the methodology, is made on the basis of point assessment system, where each factor $F_{i,j}$ is given correspondence of certain, assigned by calculation or expertise, number of points $B_{i,j}$, reflecting its influence. Obtained for all affecting factors, these points $B_{i,j}$ are put into the following formulas to determine $k_{\partial\pi}$.

$$k_{\partial\pi} = \frac{F_n}{B^*} \quad (\text{P1.8})$$

$$\text{where } F_n = \sum_{i=1}^I \sum_{j=1}^{J(i)} B_{i,j} \cdot q_{i,j} \cdot p_i$$

– probability of fault in points;

p_i – weighting factor of groups of factors (under annex 2 [98]);

$q_{i,j}$ – weighting factor of factor $F_{i,j}$ (under annex 2 [98]);

$B_{i,j}$ – point of factor $F_{i,j}$;

I – number of groups of factors;

$J(i)$ – number of factors in i group.

B^* – average point.

$$B^* = \frac{1}{N} \sum_{n=1}^N F_n \quad (\text{P1.9})$$

Let us calculate probability of fault in points F_n for a certain spot of an oil pipeline. To do this, let us first determine contribution of each factor into probability of a fault.

For instance, contribution of factor F_{11} , which characterizes the laying depth of an oil pipeline, into probability of a fault:

$$F_{11} = B_{11} \cdot q_{11} \cdot p_1$$

Value of a point, according to this methodology, for laying depth of an oil pipeline at a given section of over 0.6 metres equates null:

$$\text{then } F_{11} = B_{11} \cdot q_{11} \cdot p_1 = 0 \cdot 0,2 \cdot 0,2 = 0$$

In similar way, the values for other factors are being calculated:

$$\begin{aligned} F_{12} &= B_{12} \cdot q_{12} \cdot p_1 = 4 \cdot 0,2 \cdot 0,2 = 0,16 \\ F_{13} &= B_{13} \cdot q_{13} \cdot p_1 = 0 \cdot 0,1 \cdot 0,2 = 0 \\ F_{14} &= B_{14} \cdot q_{14} \cdot p_1 = 1 \cdot 0,1 \cdot 0,2 = 0,02 \\ F_{15} &= B_{15} \cdot q_{15} \cdot p_1 = 5 \cdot 0,15 \cdot 0,2 = 0,15 \\ F_{16} &= B_{16} \cdot q_{16} \cdot p_1 = 3 \cdot 0,15 \cdot 0,2 = 0,09 \\ F_{17} &= B_{17} \cdot q_{17} \cdot p_1 = 4 \cdot 0,1 \cdot 0,2 = 0,08 \\ F_{21} &= B_{21} \cdot q_{21} \cdot p_2 = 0 \cdot 0,2 \cdot 0,1 = 0 \\ F_{22} &= B_{22} \cdot q_{22} \cdot p_2 = 0 \cdot 0,2 \cdot 0,1 = 0 \\ F_{23} &= B_{23} \cdot q_{23} \cdot p_2 = 0 \cdot 0,1 \cdot 0,1 = 0 \\ F_{24} &= B_{24} \cdot q_{24} \cdot p_2 = 0 \cdot 0,2 \cdot 0,1 = 0 \\ F_{25} &= B_{25} \cdot q_{25} \cdot p_2 = 15 \cdot 0,14 \cdot 0,1 = 0,21 \\ F_{26} &= B_{26} \cdot q_{26} \cdot p_2 = 6,5 \cdot 0,13 \cdot 0,1 = 0,0845 \\ F_{27} &= B_{27} \cdot q_{27} \cdot p_2 = 5 \cdot 0,13 \cdot 0,1 = 0,065 \\ F_{31} &= B_{31} \cdot q_{31} \cdot p_3 = 4 \cdot 0,5 \cdot 0,05 = 0,1 \\ F_{32} &= B_{32} \cdot q_{32} \cdot p_3 = 6 \cdot 0,3 \cdot 0,05 = 0,09 \\ F_{33} &= B_{33} \cdot q_{33} \cdot p_3 = 6 \cdot 0,3 \cdot 0,05 = 0,09 \\ F_{41} &= B_{41} \cdot q_{41} \cdot p_4 = 0 \cdot 0,15 \cdot 0,1 = 0 \\ F_{42} &= B_{42} \cdot q_{42} \cdot p_4 = 10 \cdot 0,15 \cdot 0,1 = 0,15 \\ F_{43} &= B_{43} \cdot q_{43} \cdot p_4 = 2 \cdot 0,25 \cdot 0,1 = 0,05 \end{aligned}$$

$$\begin{aligned} F_{44} &= B_{44} \cdot q_{44} \cdot p_4 = 0 \cdot 0,25 \cdot 0,1 = 0 \\ F_{45} &= B_{45} \cdot q_{45} \cdot p_4 = 3 \cdot 0,1 \cdot 0,1 = 0,03 \\ F_{46} &= B_{46} \cdot q_{46} \cdot p_4 = 5,5 \cdot 0,1 \cdot 0,1 = 0,055 \\ F_{51} &= B_{51} \cdot q_{51} \cdot p_5 = 10 \cdot 0,35 \cdot 0,1 = 0,35 \\ F_{52} &= B_{52} \cdot q_{52} \cdot p_5 = 8 \cdot 0,3 \cdot 0,1 = 0,24 \\ F_{53} &= B_{53} \cdot q_{53} \cdot p_5 = 4 \cdot 0,15 \cdot 0,1 = 0,06 \\ F_{54} &= B_{54} \cdot q_{54} \cdot p_5 = 5 \cdot 0,2 \cdot 0,1 = 0,1 \\ F_{61} &= B_{61} \cdot q_{61} \cdot p_6 = 3,5 \cdot 0,5 \cdot 0,1 = 0,175 \\ F_{62} &= B_{62} \cdot q_{62} \cdot p_6 = 0 \cdot 0,2 \cdot 0,1 = 0 \\ F_{63} &= B_{63} \cdot q_{63} \cdot p_6 = 10 \cdot 0,15 \cdot 0,1 = 0,15 \\ F_{64} &= B_{64} \cdot q_{64} \cdot p_6 = 5 \cdot 0,15 \cdot 0,1 = 0,075 \\ F_{71} &= B_{71} \cdot q_{71} \cdot p_7 = 0 \cdot 0,25 \cdot 0,05 = 0 \\ F_{72} &= B_{72} \cdot q_{72} \cdot p_7 = 2,5 \cdot 0,2 \cdot 0,05 = 0,025 \\ F_{73} &= B_{73} \cdot q_{73} \cdot p_7 = 5 \cdot 0,25 \cdot 0,05 = 0,625 \\ F_{74} &= B_{74} \cdot q_{74} \cdot p_7 = 5 \cdot 0,1 \cdot 0,05 = 0,025 \\ F_{75} &= B_{75} \cdot q_{75} \cdot p_7 = 9 \cdot 0,2 \cdot 0,05 = 0,09 \\ F_{81} &= B_{81} \cdot q_{81} \cdot p_8 = 7 \cdot 0,3 \cdot 0,3 = 0,63 \\ F_{82} &= B_{82} \cdot q_{82} \cdot p_8 = 3 \cdot 0,2 \cdot 0,3 = 0,18 \\ F_{83} &= B_{83} \cdot q_{83} \cdot p_8 = 3 \cdot 0,1 \cdot 0,3 = 0,09 \\ F_{84} &= B_{84} \cdot q_{84} \cdot p_8 = 0 \cdot 0,25 \cdot 0,3 = 0 \\ F_{85} &= B_{85} \cdot q_{85} \cdot p_8 = 6,5 \cdot 0,15 \cdot 0,3 = 0,2925 \end{aligned}$$

Summing up obtained values F_{ij} , we receive:

$$\begin{aligned} F_n &= 0 + 0,16 + 0 + 0,02 + 0,15 + 0,09 + 0,08 + 0 + 0 + 0 + \\ &+ 0 + 0,21 + 0,0845 + 0,065 + 0,1 + 0,09 + 0,09 + 0 + 0,15 + \\ &+ 0,05 + 0 + 0,03 + 0,055 + 0,35 + 0,24 + 0,06 + 0,1 + 0,175 + \\ &+ 0 + 0,15 + 0,075 + 0 + 0,025 + 0,0625 + 0,025 + 0,09 + \\ &+ 0,63 + 0,18 + 0,09 + 0 + 0,2925 = 3,9695 \end{aligned}$$

Let us calculate the value of average point B^* by formula (P2.9).

$$B^* = \frac{1}{N} \sum_{n=1}^N F_n = \frac{15363,798}{4836} = 3,176964$$

where, $N = 4836$ – number of intervals on a section of an oil pipeline;

$$\sum_{n=1}^N F_n = 15363,798$$

– sum of values of probabilities of faults in points F_n on a section of an oil pipeline.

The value of probability F_n on each of other spots of a section of an oil pipeline is calculated similar to the above example.

Then, the value of influencing coefficient k_{on} on a given section, according to formula P1.8, equals:

$$k_{\text{on}} = \frac{F_n}{B^*} = \frac{3,9695}{3,176964} = 1,249$$

And, the value of specific probability of an accident, according to formula P1.7, equals

$$\lambda_n = \bar{\lambda} \cdot k_{\partial\pi} = 0,002083 \cdot 1,249 = 0,002617$$

The coefficient of severity of possible consequences of an accident is estimated by formula:

$$P_{\partial\pi} = \frac{Q_n}{Q^*} \quad (P1.10)$$

where, Q_n – point of severity of possible consequences is calculated as follows:

$$Q_n = \sum_{i=1}^I \sum_{j=1}^{J(i)} E_{i,j} \cdot q_{i,j} \cdot p_i \quad (P1.11)$$

p_i – weighting factor of groups of factors;

$q_{i,j}$ – weighting factor of factor ;

$E_{i,j}$ – point of a factor;

I – number of groups of factors;

$J(i)$ – number of factors in groupe.

Q^* – average point.

$$Q^* = \frac{1}{N} \sum_{n=1}^N E_n \quad (P1.12)$$

Let us calculate the value of a point of severity of consequences of possible accidents Q_n for this section. To do this, let us determine first the contribution of each factor.

Contribution of factor Q_{11} :

$$Q_{11} = E_{11} \cdot q_{11} \cdot p_1$$

The value of a point, according to [98], equals 0 (there is no crossing over water obstacle):

$$\text{then } Q_{11} = E_{11} \cdot q_{11} \cdot p_1 = 0 \cdot 0,3 \cdot 0,3 = 0$$

Similarly, we calculate the values for other factors:

$$Q_{12} = E_{12} \cdot q_{12} \cdot p_1 = 5,7 \cdot 0,1 \cdot 0,3 = 0,171$$

$$Q_{13} = E_{13} \cdot q_{13} \cdot p_1 = 5 \cdot 0,15 \cdot 0,3 = 0,225$$

$$Q_{14} = E_{14} \cdot q_{14} \cdot p_1 = 1,5 \cdot 0,15 \cdot 0,3 = 0,0675$$

$$Q_{15} = E_{15} \cdot q_{15} \cdot p_1 = 0 \cdot 0,2 \cdot 0,3 = 0$$

$$Q_{15} = E_{15} \cdot q_{15} \cdot p_1 = 2,5 \cdot 0,1 \cdot 0,3 = 0,075$$

$$Q_{21} = E_{21} \cdot q_{21} \cdot p_2 = 2,4 \cdot 0,2 \cdot 0,5 = 0,24$$

$$Q_{22} = E_{22} \cdot q_{22} \cdot p_2 = 1,4 \cdot 0,2 \cdot 0,5 = 0,14$$

$$Q_{23} = E_{23} \cdot q_{23} \cdot p_2 = 2,3 \cdot 0,3 \cdot 0,5 = 0,345$$

$$Q_{24} = E_{24} \cdot q_{24} \cdot p_2 = 0 \cdot 0,15 \cdot 0,5 = 0$$

$$Q_{25} = E_{25} \cdot q_{25} \cdot p_2 = 0 \cdot 0,15 \cdot 0,5 = 0$$

$$Q_{31} = E_{31} \cdot q_{31} \cdot p_3 = 2 \cdot 0,3 \cdot 0,2 = 0,12$$

$$Q_{32} = E_{32} \cdot q_{32} \cdot p_3 = 7 \cdot 0,4 \cdot 0,2 = 0,56$$

$$Q_{33} = E_{33} \cdot q_{33} \cdot p_3 = 0 \cdot 0,3 \cdot 0,2 = 0$$

Summing up obtained values Q_{ij} we receive:

$$Q_n = 0 + 0,171 + 0,225 + 0,0675 + 0 + 0,075 + 0,24 + 0,14 + 0,345 + 0 + 0 + 0,12 + 0,56 + 0 = 1,9435$$

Let us calculate the value of average point Q^* by formula (P1.12).

$$Q^* = \frac{1}{N} \sum_{n=1}^N E_n = \frac{8651,367}{4836} = 1,788951$$

where, $N = 4836$ – number of intervals on section MH

$$\sum_{n=1}^N E_n = 8651,367$$

– sum of values of points for severity of consequences of possible accidents E_n on a section of an oil pipeline.

The value of a point of severity of consequences of possible accidents E_n on each of spots of a section is calculated similar to the above example.

The value of the coefficient of severity of possible consequences $P_{\partial\pi}$ on a given section by formula P2.10 equals:

$$P_{\partial\pi} = \frac{Q_n}{Q^*} = \frac{1,9435}{1,788951} = 1,08639$$

The value of specific risk of an accident on a section of an oil pipeline, according to formula P1.1, equals:

$$R = \lambda_n \cdot p_{\partial\pi} = 0,002617 \cdot 1,08639 = 0,002843$$

The distribution of the values of specific risks on a route of a main oil pipeline by its nature corresponds to the distribution of specific frequency of accidents, given in Figure A1.1.

Obtained assessments of risk of accidents on an oil pipeline are the basis for developing priority measures to enhance safety of an oil pipeline. For example, when planning the distribution of volumes of repairs along the length of a pipeline, priorities are those areas where the value of specific risk is greater.

Annex 3

An example of calculation of risks for an on-site facility

For an on-site facility, the main parameter of risk is the possibility of human injury or death from an accident at this production facility. This parameter is referred to as *an individual risk* and describes the numerical value of frequency with which the situation, causing damage to human health, may arise. In addition to the individual risk, there is a concept of a *collective risk*, which indicates frequency with which there may arise a threat to health of a group of people.

Let us have an example of calculating the individual risk for a person who is a worker of one of the units (services) on an oil pumping station and an example of calculating the collective risk, i.e. the risk of injury or death faced by the entire staff of such facility. This unit can be a repair service, administration, communication service, corrosion protection service, economic group, security, etc. This example assumes it to be unit No. 1, unit No. 2, unit No. 3, etc.

These calculations are pursuant to the current regulatory documents in Belarus.

For the calculation of the individual and collective risks, possible potential threats are being analysed and possible scenarios of an accident at the given production facility are being drafted.

If we consider each threat and take into account every possible direction of an accident's development, in this case the number of the accident's scenarios would be tens of thousands.

Let us consider any single scenario for a pumping station. The scenario shall include a sequence of events, occurring one after the other or inducing one another. We would call it a "scenario under review" and designate it as C_p .

Let us put down the sequence of possible events for a tank of a pumping station (hereinafter – VST (vertical stock tank), which was struck by lightning.

C_p : lightning protection system failure → lightning strike into the tank → failure of flame trap pressure vent valves and an explosion in the tank with instant ignition of oil → complete destruction of the tank → burning of oil spills within the bund.

The result of this scenario is an explosion of oil vapor inside the tank, which shall lead to the destruction of the tank and injury or death of people in the vicinity, as well as the burning of spilled oil within the bund, designed to prevent oil spreading on the territory of the pumping station.

Risk of injury (or death) of a person or personnel will be determined by the product of the probability of the implementation of this scenario and the probability of their injury (or death).

P1.1. Calculation of probability of implementation of this scenario.

When calculating the probability of fire (explosion), let us take into account simultaneity of several events leading to the fire (explosion):

- The presence of a lightning strike;
- The presence of a failure of lightening protection system when lightning strikes;
- The presence of flame trap failure;
- The presence of vapor-air mixture above the tank, which can ignite from lightning strike when lightning protection system fails.

The probability of oil ignition shall consist in the implementation of two events: the presence of an ignition source and the presence of the possibility of ignition of oil. The probability of the first event shall be determined by the probability of a lightning strike and the probability of failure of the lightning protection system. The probability of the second event is determined by the probability of failure of flame trap pressure vent valves, as well as the conditional probability of an explosion in the tank of vapor phase, which is above the oil liquid level, and the conditional probability of instant ignition of oil liquid caused by an explosion of vapor phase in the tank.

The probability of an explosion of vapor and ensuing oil burning is calculated under annex 3 [96] by formula:

$$P_{\text{of explosion and burning}} = 1 - \prod_{i=1}^K (1 - P_i) \quad (\text{P2.1})$$

where $P_{\text{of explosion and burning}}$ – probability of explosion of vapor and ensuing oil burning;

P_i – probability of i event which is a part of the scenario;

K – number of events which are a part of this scenario.

We assume:

Probability of lightning protection system failure (under p.6.4 [102]) is $1 \cdot 10^{-5}$;

Probability of a lightening strike into the tank is determined according to p.3.1.3. of annex 3 to [96] and is $5.43 \cdot 10^{-3}$;

Probability of failure of flame trap pressure vent valves (under p.1.1. [96]) is $1 \cdot 10^{-6}$
 Probability of the presence of vapor in VST is 1;
 Conditional probability of an explosion of vapor phase, which is above the oil liquid level in the tank [103], is 0.2;
 Conditional probability of instant ignition of oil liquid caused by an explosion of vapor phase in the tank [103] is 0.05.

We put the values into formula (P2.1) and receive:

$$P_{\text{of explosion and burning}} = 1 - (1 - 5.43 \cdot 10^{-3} \cdot 1 \cdot 10^{-5}) \cdot (1 - 1 \cdot 10^{-6} \cdot 1 \cdot 0.2 \cdot 0.05) = 6.43 \cdot 10^{-8}$$

Therefore, the probability of oil burning is $6.3899 \cdot 10^{-8}$.

As the explosion of oil vapor can result in the destruction of the tank, then the probability of the implementation of the whole scenario shall be determined by overlapping of these two events and shall be:

$$P(C_p) = 6.43 \cdot 10^{-8} \cdot 5 \cdot 10^{-6} = 3.21 \cdot 10^{-13}$$

where $6.43 \cdot 10^{-8}$ – probability of an explosion and fire,
 $5 \cdot 10^{-6}$ – probability of complete destruction of the tank.

P1.2. Calculation of conditional probability Q_{bni} of a casualty due to excess pressure during explosions

Let us calculate the conditional probability Q_{bni} of a person being affected by excess pressure during explosions, depending on his/her location [97] at distance r from the epicenter of an explosion. To do this:

- we calculate excess pressure ΔP and impulse i ;
- based on values ΔP and i , we calculate the value of probit-function P_r by formula:

$$P_r = 5 - 0.26 \cdot \ln(V) \quad (P2.2)$$

where V – a value which equals:

$$V = \left(\frac{17500}{\Delta P} \right)^{8.4} + \left(\frac{290}{i} \right)^{9.3} \quad (P2.3)$$

where ΔP – excess pressure, Pa;
 i – impulse of pressure wave, Pa · s.

Let us make calculation to determine conditional probability Q_{bni} of a casualty due to excess pressure from an explosion for scenario C_p .

The value of excess pressure ΔP , kPa, produced by burning of gas-vapor-air mixtures, is determined by formula:

$$\Delta P = P_o \cdot (0.8m_{np}^{0.33}/r + 3m_{np}^{0.66}/r^2 + 5m_{np}/r^3) \quad (P2.4)$$

where P_o – atmospheric pressure, (can be assumed to equal 101 kPa) kPa;

r – distance from geometric center of gas-vapor-air cloud, m;

m_{np} – equivalent mass of gas or vapor, kg, is calculated by formula:

$$m_{np} = (Q_{cr}/Q_o) \cdot m \cdot Z \quad (P2.5)$$

where Q_{cr} – specific heat of burning of gas or vapor, J · kg⁻¹;
 Z – coefficient of the participation of flammable gases and vapors in the process of burning, which can be assumed to equal 0.1;

Q_o – constant value which equals $4.52 \cdot 10^6$ J · kg⁻¹;

m – mass of flammable gasses and (or) vapors which leaked during the accident into the environment, kg.

The value of impulse of pressure wave i , Pa · s, is calculated by formula:

$$i = 123 \cdot \tau_{np}^{0.66}/r \quad (P2.6)$$

Let us give an example of calculation for the scenario of explosion in the tank C_p .

We shall determine equivalent mass of oil vapors in VST. Specific heat of burning of oil vapors Q_{cr} equals 4.4 MJ/kg. The mass of oil vapors is given in table 5.2.10:

In this case, an equivalent mass of oil vapors by formula (P2.5) equals:

$$m_{np} = (Q_{cr}/Q_o) \cdot m \cdot Z = (4.4 \cdot 10^6 / 4.52 \cdot 10^6) \cdot 1960 \cdot 0.1 = 190.8 \text{ kg}$$

As an example, using the formula (P2.4), we calculate the value of excess pressure ΔP , kPa, produced by burning of oil vapors at distance $r=30$ m from geometric center of an explosion:

$$\begin{aligned} \Delta P &= P_o \cdot (0.8m_{np}^{0.33}/r + 3m_{np}^{0.66}/r^2 + 5m_{np}/r^3) = \\ &= 101.3 \cdot (0.8 \cdot 190.8^{0.33}/30 + 3 \cdot 190.8^{0.66}/30^2 + 5 \cdot 190.8/30^3) = \\ &= 29.7 \text{ kPa} \end{aligned}$$

Let us determine the value of impulse of pressure wave i , Pa · s:

$$i = 123 \cdot 190.8^{0.66}/30 = 131.2 \text{ Pa} \cdot \text{s}$$

Calculated values of excess pressure and wave impulse for various distances from the geometric center of an explosion for the scenario under review are given in Table A2.1.

Table A2.1. Value of excess pressure of wave front of explosion and pressure impulse.

Destruction radius R, m	Value of excess pressure of shock wave ΔP , kPa	Impulse of pressure wave i , Pa·s
7	545.71	562.32
8	398.01	492.03
9	303.57	437.36
10	239.74	393.62
11	194.66	357.84
12	161.67	328.02
13	136.80	302.79
14	117.58	281.16
15	102.42	262.42
16	90.24	246.01
17	80.29	231.54
18	72.06	218.68
19	65.16	207.17
20	59.32	196.81
21	54.32	187.44
22	50.01	178.92
23	46.26	171.14
24	42.98	164.01
25	40.08	157.45
26	37.52	151.39
27	35.23	145.79
28	33.18	140.58
29	31.33	135.73
30	29.67	131.21
31	28.15	126.98
32	26.77	123.01
33	25.51	119.28
34	24.36	115.77
35	23.29	112.46
36	22.31	109.34
37	21.40	106.38
38	20.56	103.59
39	19.78	100.93
40	19.05	98.41
41	18.37	96.01
42	17.73	93.72
43	17.14	91.54
44	16.58	89.46
45	16.05	87.47
46	15.56	85.57
47	15.09	83.75
48	14.65	82.00
49	14.23	80.33
50	13.83	78.72

Let us calculate value V . The value of excess pressure and the value of wave impulse are taken from calculation for distance $r=30\text{m}$ from the geometric center of an explosion. In this case V equals:

$$V = \left(\frac{17500}{\Delta P} \right)^{8.4} + \left(\frac{290}{i} \right)^{9.3}$$

$$= \left(\frac{17500}{29700} \right)^{8.4} + \left(\frac{290}{131.21} \right)^{9.3} = 1597.79$$

Let us calculate the value of probit-function P_r :

$$P_r = 5 - 0.26 \cdot \ln(V) = 5 - 0.26 \cdot \ln(1597.79) = 3.08$$

On the basis of *Table A2.2* [97], we determine the conditional probability of a casualty for probit-function P_r .

Table A2.2. Value of conditional probability of a casualty, depending on the value of "probit-function".

Conditional probability of casualty, %	Value Pr									
	0	1	2	3	4	5	6	7	8	9
0	–	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
10	3.72	3.77	3.82	3.9	3.92	3.96	4.01	4.05	4.08	4.12
20	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
30	4.48	4.5	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
40	4.75	4.77	4.8	4.82	4.85	4.87	4.9	4.92	4.95	4.97
50	5	5.03	5.05	5.08	5.1	5.13	5.15	5.18	5.2	5.23
60	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.5
70	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
80	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
90	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33
99	7.33	7.37	7.41	7.46	7.51	7.58	7.65	7.75	7.88	8.09

In case of $r=30\text{m}$, it will be 2.8%. Values for other distances are given in Table A2.3.

Table A2.3. Conditional probability of a casualty.

Distance from geometric center of explosion R, m	Pressure difference in a shock wave P, kPa	Impulse of pressure wave i, Pa·s	Value V for probit-function	Probit-function Pr	Conditional probability of casualty $Q_{np,i}$, %
7	545.71	562	0.002	6.60	94.5
8	398.01	492	0.007	6.28	90
9	303.57	437	0.022	5.99	84
10	239.74	394	0.058	5.74	77
11	194.66	358	0.142	5.51	69.5
12	161.67	328	0.318	5.30	62
13	136.80	303	0.669	5.10	54
14	117.58	281	1.334	4.93	47.3
15	102.42	262	2.533	4.76	40.5
16	90.24	246	4.617	4.60	34.5
17	80.29	232	8.114	4.46	39.7
18	72.06	219	13.806	4.32	24.8
19	65.16	207	22.827	4.19	21
20	59.32	197	36.781	4.06	17.4

The calculation results of conditional probability of casualties in different units (services) of a company for scenario C_p under review are given in Table A2.4.

Table A2.4. Conditional probability of casualties.

Location of people	Q-ty of people in a unit (service), pcs	Distance to the center of an explosion, m	Probit-function Pr	Conditional probability of casualty $Q_{np,i}$, %
Unit No. 1	6	49	5.57	72
Unit No 2	6	62	5.00	50
Unit No 3	12	64	4.92	47
Unit No 4	11	66	4.85	44
... and such	9	201	2.13	0
Unit No n	3	90	4.09	18

where n – number of units at a given facility.

It must be noted that the methodology used in the calculation does not account for the presence of people in the buildings, shelters, behind obstacles, etc., i.e. during an actual explosion of fuel-air mixture, the probability of casualties will be much lower.

In addition to a possible injury (or death) of people from shock wave, there can be injury (or death) from thermal emission caused by oil burning. The probability of such impacts shall be determined in the next section.

P1.3. Calculation of the conditional probability of a casualty due to thermal emission Q_{fni}

In order to calculate the conditional probability of a person being affected due to thermal emission Q_{fni} , first it is necessary to calculate the value of "probit-function" P_r by formula (P1.5):

$$P_r = -14.9 + 2.56 \cdot \ln(t \cdot q^{1.33}) \quad (P2.7)$$

where t – effective time of exposure, s;
 q – intensity of thermal emission, $\text{kW} \cdot \text{m}^{-2}$.

The value of the effective time of exposure t for fires produced by spills can be calculated as follows:

$$t = t_o + x/v \quad (P2.8)$$

where t_o – typical time for detecting fire, s (it is assumed to be $t = 5$ s);

x – distance from a person's location to a zone where the intensity of thermal emission does not exceed $4 \text{ kW} \cdot \text{m}^{-2}$; m;

v – speed of person's movement, $\text{m} \cdot \text{s}^{-1}$ (for Eastern Europe it is assumed to be $v = 5 \text{ m} \cdot \text{s}^{-1}$).

Let us calculate conditional probability Q_{fni} of a casualty due to thermal emission for scenario C_p with oil burning inside the tank.

The distance from the edge of the tank wall to the area where intensity of thermal emission does not exceed $4 \text{ kW} \cdot \text{m}^{-2}$ is 29.9 m. In our example, the nearest spot of a person's location to the given tank is building of Unit No.2 which is at a distance of 62 m. This spot is not included in the area where intensity of thermal emission can exceed $4 \text{ kW} \cdot \text{m}^{-2}$. Therefore, the distance from the location of a person to the area where intensity of thermal emission does not exceed $4 \text{ kW} \cdot \text{m}^{-2}$ equals null. So, the effective exposure time shall equal:

$$t = t_o + x/v = 5 + 0/5 = 5 \text{ s}$$

Let us calculate the value of probit-function:

$$P_r = -14.9 + 2.56 \cdot \ln(t \cdot q^{1.33}) = -14.9 + 2.56 \cdot \ln(5 \cdot 0.617^{1.33}) = 1.32$$

From table 9 [97] we determine the conditional probability of a casualty due to thermal emission for probit-function P_r which amounts to 1.32.

The conditional probability of a casualty due to thermal emission at the given value of probit-function equals 0%.

The obtained results for other distances for this scenario C_p are given in Table A2.5.

After receiving the results of conditional probability of casualties due to thermal heat, the value of individual risk can be determined.

Table A2.5. Conditional probability of a casualty due to thermal emission.

Distance from geometric center of burning, m	Intensity of thermal emission q , kW/m^2	Probit-function P_r	Conditional probability of casualty, %
10	99.586	5.74	77
15	37.202	4.76	41
20	17.187	4.06	17
25	9.160	3.52	7
30	5.402	3.08	2.8
35	3.433	2.71	1.1
40	2.309	2.39	0
45	1.623	2.10	0
50	1.182	1.85	0
55	0.887	1.62	0
60	0.682	1.41	0

P1.4. Calculation of the value of individual risk for personnel of an oil pump station.

The value of individual risk, according to [97], we determine by formula:

$$R_{\partial} = \sum_{i=1}^n Q_{\partial i} \cdot Q_{\partial ni} \quad (P2.9)$$

where: $Q_{\partial i}$ – probability of occurrence of i accident, 1/year;
 $Q_{\partial ni}$ – conditional probability of casualties;
 n – number of types of accidents under review.

Example. Let us calculate the value of individual risk for a person who is in the building of Unit No. 1.

During implementation of single scenario C_p (the probability of implementation $3.2 \cdot 10^{-13}$) the probability of casualties is 72%, i.e. the individual risk is:

$$R(C_p) = 3.2 \cdot 10^{-13} \cdot 0.72 = 2.3 \cdot 10^{-13} \text{ life/year}$$

To calculate overall individual risk, we take into account all scenarios of accidents where there is probability of a person affected who is working in a specific unit.

By this time, we have calculated the values of probabilities of all possible accidents, as well as the probability of affecting this person at the implementation of each scenario. We make calculation:

$$R_{\text{unitNo.1}} = 8.3 \cdot 10^{-10} \cdot 0.72 + 8.3 \cdot 10^{-10} \cdot 0.72 + 3.2 \cdot 10^{-13} \cdot 0.72 + 3.2 \cdot 10^{-13} \cdot 0.72 + 9.81 \cdot 10^{-20} \cdot 0.72 + \dots + 1.3 \cdot 10^{-10} \cdot 0.72 + 5 \cdot 10^{-14} \cdot 0.72 + 5 \cdot 10^{-14} \cdot 0.72 + 7.69 \cdot 10^{-26} \cdot 0.72 + 7.69 \cdot 10^{-26} \cdot 0.72 = 1.38 \cdot 10^{-9} \text{ 1/year}$$

The results of calculation of individual risk for personnel of each unit are given in *Table A2.6*.

Based on the values of individual risk, the territories are mapped to indicate fields of risk, which has the same values of risk in some areas.

Let us determine the value of the collective risk to personnel of a production facility.

The connection of individual risk of a worker $R_{\text{инд } i}$ and collective risk of personnel from accidents $R_{\text{кол}}$ sets correlation

$$R_{\text{колл}} = \sum_{i=1}^m R_{\text{инд } i} \quad i. \text{ year}^{-1} \quad (P2.10)$$

where m – number of workers.

Table A2.6. Assessment of individual risk.

Scenario	Probability of scenario implementation	Probability of casualties					
		Unit No. 1	Unit No. 2	Unit No. 3	Unit No. 4	Unit No. 5	... and other units
$C_{\text{vst No18.14}}$	$3.2 \cdot 10^{-13}$	0.72	0.5	0.47	0.44	0	...
Another scenario No. 1	$8.3 \cdot 10^{-10}$	0.72	0.5	0.47	0.44	0	...
Another No. 2	$8.3 \cdot 10^{-10}$	0.72	0.5	0.47	0.44	0	...
Another scenario No. 3	$3.2 \cdot 10^{-13}$	0.72	0.5	0.47	0.44	0	...
... and other scenarios
$R_{\text{инд } i} \cdot \text{year}^{-1}$		$1.38 \cdot 10^{-9}$	$1.07 \cdot 10^{-9}$	$8.5 \cdot 10^{-10}$	$7.98 \cdot 10^{-10}$	$7.02 \cdot 10^{-12}$	$3.33 \cdot 10^{-10}$

Let us put calculation data into *Table A2.7*.

Table A2.7. Assessment of collective risk.

Location of personnel	Unit No. 1	Unit No. 2	Unit No. 3	Unit No. 4	Unit No. 5	... and other units
Q-ty of personnel	6	6	12	11	9	...
Value of individual risk	$1.38 \cdot 10^{-9}$	$1.07 \cdot 10^{-9}$	$8.5 \cdot 10^{-10}$	$7.98 \cdot 10^{-10}$	$7.02 \cdot 10^{-12}$...

Let us determine the value of collective risk:

$$R_{col} = 1.38 \cdot 10^{-9} \cdot 6 + 1.07 \cdot 10^{-9} \cdot 6 + 8.5 \cdot 10^{-10} \cdot 12 + 7.98 \cdot 10^{-10} \cdot 11 + 7.02 \cdot 10^{-12} \cdot 9 + \dots = 7.81 \cdot 10^{-8}, \text{ personnel of a facility/year}$$

According to the regulatory documents of Belarus, the risk to **personnel** is regarded as *indisputably acceptable*, if individual risk is less than 10^6 year^{-1} and indisputably unacceptable, if individual risk is greater than 10^4 year^{-1} . If individual risk ranges from 10^6 to 10^4 year^{-1} , the risk is assumed to be in the *area of strict control*. In this area the risk is considered acceptable, in case certain measures are taken that reduce it as much as it can be practicable. This should meet the following requirements: presence in the danger zone with high potential risk of a limited number of people for a limited period of time; company's staff is well trained and ready to act to localize and mitigate fires and fire hazardous situations; there is a proven warning system in case of fire and fire hazardous situations.

Maximum allowable values of acceptable fire risk to **population**, residing in the territory which is adjacent to an industrial enterprise, due to its industrial activities are being regulated [100]. The risk to population is assumed as *indisputably acceptable*, if individual risk is less than $10^{-8} \text{ year}^{-1}$. The risk to population is assumed as *indisputably unacceptable*, if individual risk is greater than $10^{-6} \text{ year}^{-1}$. If individual risk ranges from 10^{-8} to $10^{-6} \text{ year}^{-1}$, it is assumed that fire risk is in the zone of strict control. The risk in this zone is assumed as acceptable, in case certain measures are taken which reduce it as much as it can be practicable. Moreover, there must be a proven warning system in case of fire and fire hazardous situation.

It must be noted that in our example, based on the calculations, an individual risk to personnel is in the category of indisputably acceptable that suggests low risk of this production facility to its personnel.

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