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Subject review

Development of Model of Risk-Based Approach to the Formation of Industry Standard in the Field of Occupational Safety and Health at Liquefied Natural Gas Bunkering Facilities

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Abstract: The aim of the study is to increase the level of industrial safety of enterprises engaged in bunkering of liquefied natural gas (LNG) for shipment by sea. The objectives of the study are to conduct a comprehensive and structural analysis of the production and transportation of LNG, identify promising and economically significant projects for the sale of LNG for export and Russian market, prepare a matrix of regulatory legal regulation in the field of requirements for industrial facilities implementing LNG supplies. The main criteria are requirements, presented to the transport and unloading hub, ports, factories, education and training of staff, ensuring the performance of technological operations. The hypothesis of the study is to identify gaps in the existing legislation, which are proposed to be filled by developing a risk management concept that will not only ensure the identification of risks at individual production sites, but also allow to determine the structure of the occupational health and safety management system, requirements for personal protective equipment, development and the introduction of barriers to potential danger, as well as prevention of emergencies and emergency situations. The result of the research is a concept based on a risk-based approach to managing an organization.

Keywords: bunkering of sea vessels; environmental safety; liquefied natural gas; man-made risk management; occupational safety management; system of occupational safety and health standards

1 INTRODUCTION

Despite the fact that Russia is the largest exporter of LNG, there is a technological lag in the country in this field. Today, the situation is aggravated in the context of international technological sanctions: the United States' law of August 2, 2017 on additional sanctions against Russia may affect the "Baltic LNG" construction project and the construction of the third production line of LNG plant within the project "Sakhalin-2", carried out jointly with the Dutch-British energy company Royal Dutch Shell.

Currently, the only sources of Russian LNG export supplies are the "Sakhalin-2" project with a production capacity of 10.8 million tons/year, in which Gazprom is the main shareholder, and the "Yamal LNG" project with a production capacity of 16.5 million tons/year ("Novatek"). In the long term, until 2035, the country's large-scale LNG production capacity may increase to 76 million tons/year. The main participants in the business process will be large oil and gas companies of Russia: Gazprom, Novatek and Rosneft Oil Company.

This perspective is associated not only with ensuring the development of gas condensate in Russian region, but also with the risks of emergencies. Haste in building the capacity of program implementation can lead to a disdain for ensuring labor protection, training specialists, equipping them with proper means of collective and individual protection.

One of the priority tasks is to assess the existing national and international regulatory legal documents in the field of LNG bunkering. Such a comparison will allow seeing the legal picture of the regulation of technological processes and developing a proposal for the harmonization and adaptation of industry standards.

The next task is to develop and prepare proposals to compensate for the missing regulation elements by controling the internal rules and regulations of the organization at technological facilities.

The object of research is the occupational health and safety management system at the enterprises of development, operation and bunkering of LNG.

The subject of this research is a structural risk-oriented analysis of the most promising projects implemented in special economic zones of Russia in the field of LNG bunkering for shipment by sea.

The priority goal is to prepare proposals for the creation of an industry standard in the field of bunkering of LNG tankers, which fully reflects the main methods of risk management, health and safety systems and environmental safety.

2 THEORETICAL BASIS

Analysis of economic development for the future until 2025 shows an increase in the development of useful LNG capacity by at least 2 times, which means the corresponding development of territories and the provision of infrastructure for promising Russian regions (Fig. 1) [1-3].

At the current stage of development of LNG bunkering market, this insignificant list of standardization documents is not a "bottleneck", since already now in Russia fundamental international technical standards have been translated and adopted as a whole [4].

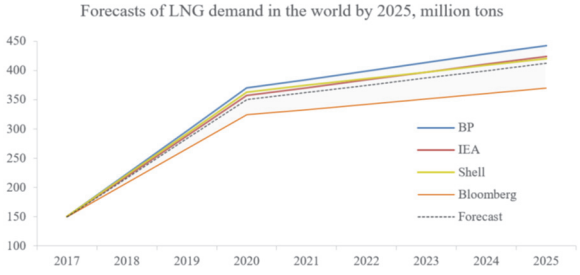

Figure 1 Forecast of LNG demand up to 2025

In Russia, the market for LNG bunkering is practically absent; at the same time, now in Russia there are some peculiarities of the legislation that impede the development of the market, the elimination of which can help to activate the market. The first limitation is the lack of separation of gas transportation by other means (except for pipelines) as

a separate type of activity in the Federal Law [5-7]. This creates legal restrictions on the development of economic relations in this area.

There is also no unambiguous interpretation of legislation regarding the classification of LNG bunkering activities as licensed ones, as well as the classification of activities as natural monopolies. The classification of LNG bunkering as a type of activity "loading and unloading of goods" is applied, which is included in the list of services provided by natural monopoly entities [8] and, therefore, is subject to government regulation. However, this is not happening now. Therefore, clarification is required regarding the belonging of LNG bunkering to natural monopolies.

Market participants also note administrative restrictions regarding the lease and purchase of land plots for organizing LNG bunkering activities [9].

Currently, there is a work to translate and adapt international ISO standards and individual directives in Russia, as well as the rules of the European Union. The table summarizes all currently valid standards in the field of LNG bunkering.

Table 1 Standards for LNG bunkering

Level / Area	Requirements for the operation of LNG terminals and ports	LNG production	LNG transportation (delivery to the bunkering facility)	LNG bunkering process / interface requirements	Requirements for a bunker vessel / operation of a vessel using gas engine fuel	Requirements for the design (including equipment) of LNG production and distribution facilities	Requirements for the training of specialists and staff
International (high) level			MARPOL, SOLAS, ADR, ADN	IGF Code	IGF Code, SOLAS, MARPOL		STCW
Technical standards	GOST R ISO 18132.1-2-2017 GOST R 56352-2015 GOST R ISO 28460-2018	GOST R 55892-2013		GOST R 57433-2017 GOST R ISO 28460-2018	GOST R 57433-2017 GOST R ISO 18132.1-2-2017	GOST R 55892-2013 GOST R ISO 18132.1-2-2017 GOST R 57431-2017	
Class rules for ships or port infrastructure	Order of the Ministry of Transport of the Russian Federation, October 26, 2017 № 463				Order of the Ministry of Transport of the Russian Federation, October 26, 2017 No. 463	Order of the Ministry of Transport of the Russian Federation, October 26, 2017 № 463	
Industry guidelines	Set of Rules 240.1311500.2015	Set of Rules 326.1311500.2017				Order of the Federal Service for Environmental, Technological and Nuclear Supervision № 588, November 26, 2018 Set of Rules 326.1311500.2017	
Port requirements and local regulatory framework	Resolution of the Government of the Russian Federation, April 23, 2008 № 293	Federal Law № 69-FZ "On Gas Supply in the Russian Federation"		Resolution of the Government of the Russian Federation, April 23, 2008 № 293		Order of the Federal Technical Regulation and Metrology Agency July 30, 2018 № 1600	

3 METHODOLOGY

On April 9, 2019, within the framework of the V International Arctic Forum "Arctic is a Territory of Dialogue", Gazprom, Federal Technical Regulation and Metrology Agency (Technical Committee 23) and the Ministry of Industry and Trade of the Russian Federation signed a Program for Standardization of Technology Development and Technology in the field of oil refining, petrochemicals, processing and liquefaction of natural gas, including for projects on platforms (foundations) of the gravity type with technological lines for LNG production, as well as vessels carrying out LNG transportation. The implementation of the Program is calculated until 2023. It is planned to develop and consolidate at the state level uniform standards based on modern requirements for the design and production of equipment and construction materials for medium and large-scale LNG production, for oil and gas chemistry and its processing facilities.

However, this program does not have open access, but taking into account the results of the analysis given in the previous sections, the following proposals can be formed with respect to proposals for the development/harmonization of regulatory documents of the Russian Federation and documentation of Gazprom standardization system:

1. For Russian Federation:

- similar to the Directive for the creation of an infrastructure for alternative fuels European Union 2014/94, it is necessary to create a targeted plan for the development of LNG bunkering market in Russia in continuation of the current strategic planning documents, with the obligatory indication of specific measurable indicators in order to attract private investors;
- translation and adaptation of the fundamental international standard in the field of LNG bunkering at present: EN ISO 20519 Specification for the bunkering of ships operating on LNG and related documents;

- making adjustments to the approximate federal educational standards (Order of the Ministry of Education and Science of Russia, August 02, 2013, № 857 "On the approval of the Federal State Educational Standard for vocational education 180403.2 "Sailor", etc.), as well as training programs for specialists in maritime affairs and developing educational qualifications of specialists involved in LNG bunkering operations, as prescribed by the International Convention on the Training, Certification and Watchkeeping of Seafarers;
- by analogy with the Rules for the Organization of Navigation on the Rhine (Central Commission for Navigation of the Rhine) in the development of the Orders of the Ministry of Transport of the Russian Federation № 463b October 26, 2017, supplement the requirements for the operation of Russian ports with the Control Rules, namely: the introduction of checklists (checklists) for all possible types of LNG bunkering interfaces or translate and ratify the International Association of Ports and Harbors (IAPH) rules for bunkering control used by a number of river/sea ports in Europe [10, 11]:
- considering that at present, within the framework of technical regulation of LNG industry, the requirements for structural materials and equipment in general used in relation to LNG are applied to a cryogenic liquid (fire requirements and when acting in hazardous situations, etc.), it is advisable to carry out the development or ratification of international standards, similar to EN ISO 16903-Characteristics of LNG, influencing the design, and material selection and EN ISO 16904-Design and testing of LNG marine transfer arms for conventional onshore terminals (Design and testing of offshore LNG transmission lines for conventional land terminals);

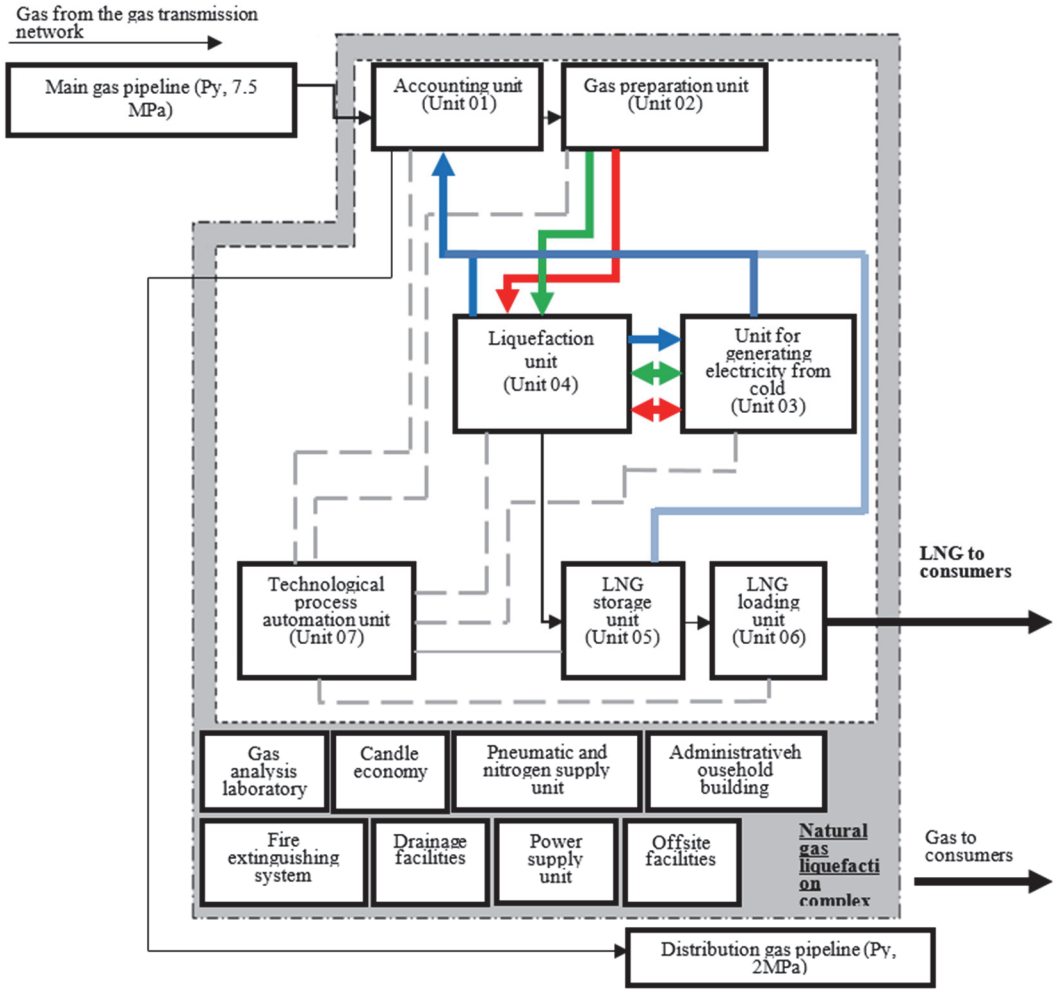

Figure 2 Block diagram of LNG bunkering production process

2. For Gazprom:
- to develop an internal standard for the implementation of LNG bunkering process, similar to the existing guidelines for LNG bunkering, which have been developed by industry organizations or international associations in the development of international standards ISO/TS 18683 and EN ISO 20519 in order to support the development of the LNG bunkering market, for example, IACS Rec 142 LNG Bunkering Guidelines (International Association of Classification Societies) or LNG Bunkering Guidelines. Safety Guidelines (Society for the Use of Gas as Marine Fuel) [12, 13];
- to prepare an internal list of qualifications for recruiting staff, guided by the minimum competencies that must be possessed by employees working on ships and in ports involved in LNG bunkering operations, in accordance with the International Convention for the Prevention of Marine Pollution from Ships and the international standard EN ISO EN ISO 20519-Specification for bunkering ships fuelled by LNG;

- in order to minimize risks, to introduce standards for equipment, lines, hoses, materials used when working with LNG, in particular, when bunkering LNG, by analogy with, for example, Organization standard of Gazprom 2-4.1-713-2013 "Technical requirements for pipes and fittings".

3.1 Analysis of LNG Production Process Systems Prior to Shipment

To achieve this goal, the main criteria for the significance of the management process were selected. In accordance with the selected criteria for the bunkering process, the main stages of the process are:

- requirements for the operation of LNG terminals and ports;
- LNG production;
- LNG transportation (delivery to the bunkering facility);
- LNG bunkering process/interface requirements;
- requirement for a bunker vessel/operation of a vessel using gas engine fuel;
- design requirements (including equipment) of LNG production and distribution facilities;
- requirements for the training of specialists and staff.

Since today these processes do not have appropriate guidelines and standards from the state, the enterprise must establish these requirements in its concept. In order to apply the methods of a risk-based approach to labor safety management, it is necessary to analyze the key stages of the production process. To ensure comprehensive safety at all stages of the process, we consider in more detail the mechanism of LNG bunkering. The enlarged diagram is shown in Fig. 2.

4 RESULTS

The approximate distribution of LNG process should be consolidated as a guiding work plan. This will allow all participants in the process to understand the structure and such planning simplifies the management scheme, since each block can be considered in particular and the risk parameters can be calculated for individual elements and entire process in general. The management system must meet the necessary sufficient criteria for acceptable risk for operational countering by the parameters of the system elements. Each participant in the process should be involved in the management process and be guided by the concept when making a decision.

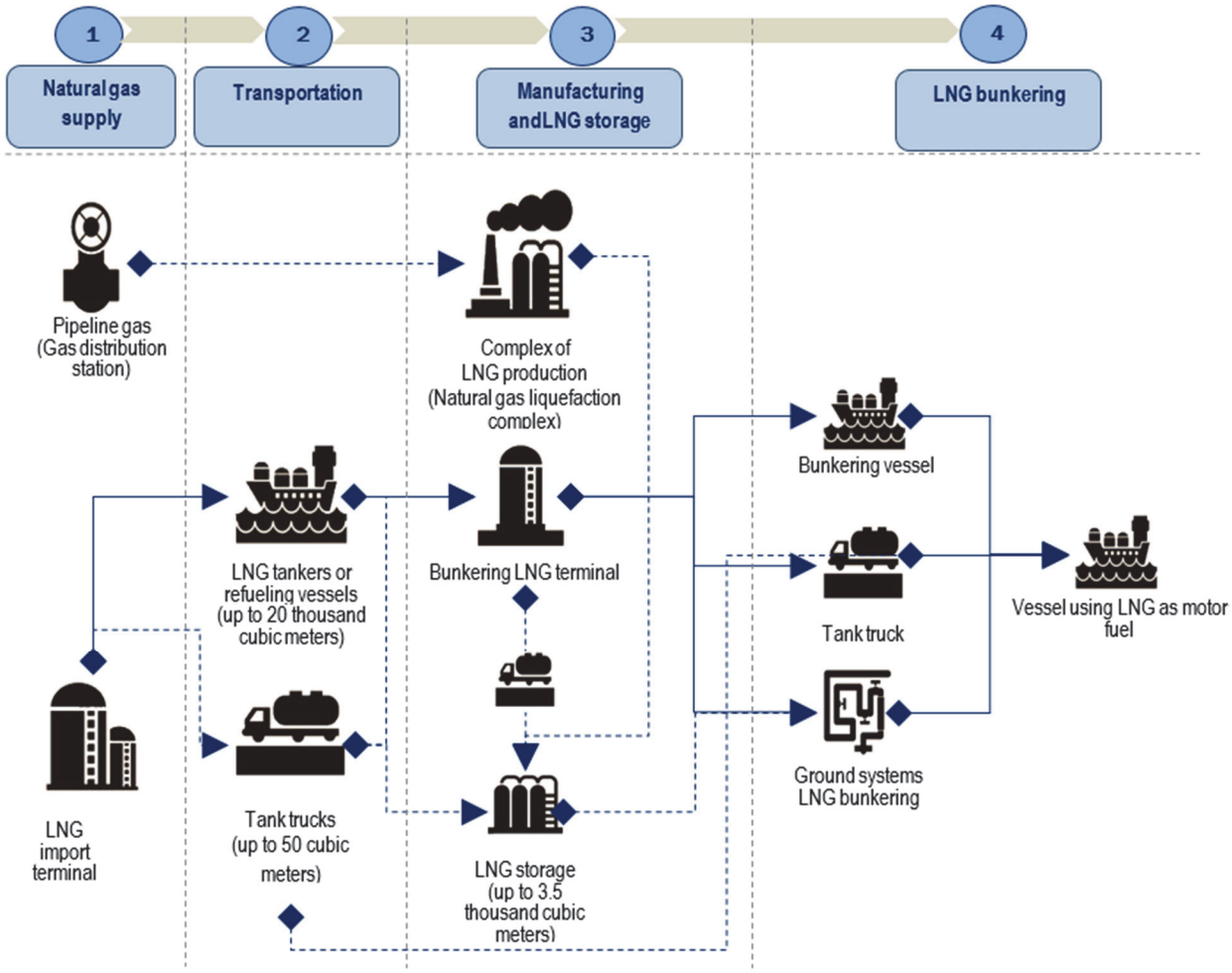

Figure 3 Scheme of the LNG supply process

We focus on the process of bunkering and shipping LNG by sea (Fig. 3), since this particular type of transport is proposed as the most promising one in ongoing projects [2, 3].

In terms of developing requirements for terminals and LNG transportation, it is necessary to be guided by the underlying principles. In this regard, the concept for risk management should contain the main projects that regulate the structure of the production process at all its stages.

When choosing methods of risk assessment, an organization should study in more detail all the world experience accumulated in this area, or involve highly qualified specialists in risk assessment. This approach will allow for a high-quality study of the management process, as well as increase the efficiency of the planned activities.

5 DISCUSSION

The relation between the principles of risk management, the system in which it manifests itself and the risk management process is shown in Fig. 4. Risk assessment consists of sequential stages of risk identification, risk analysis and risk assessment.

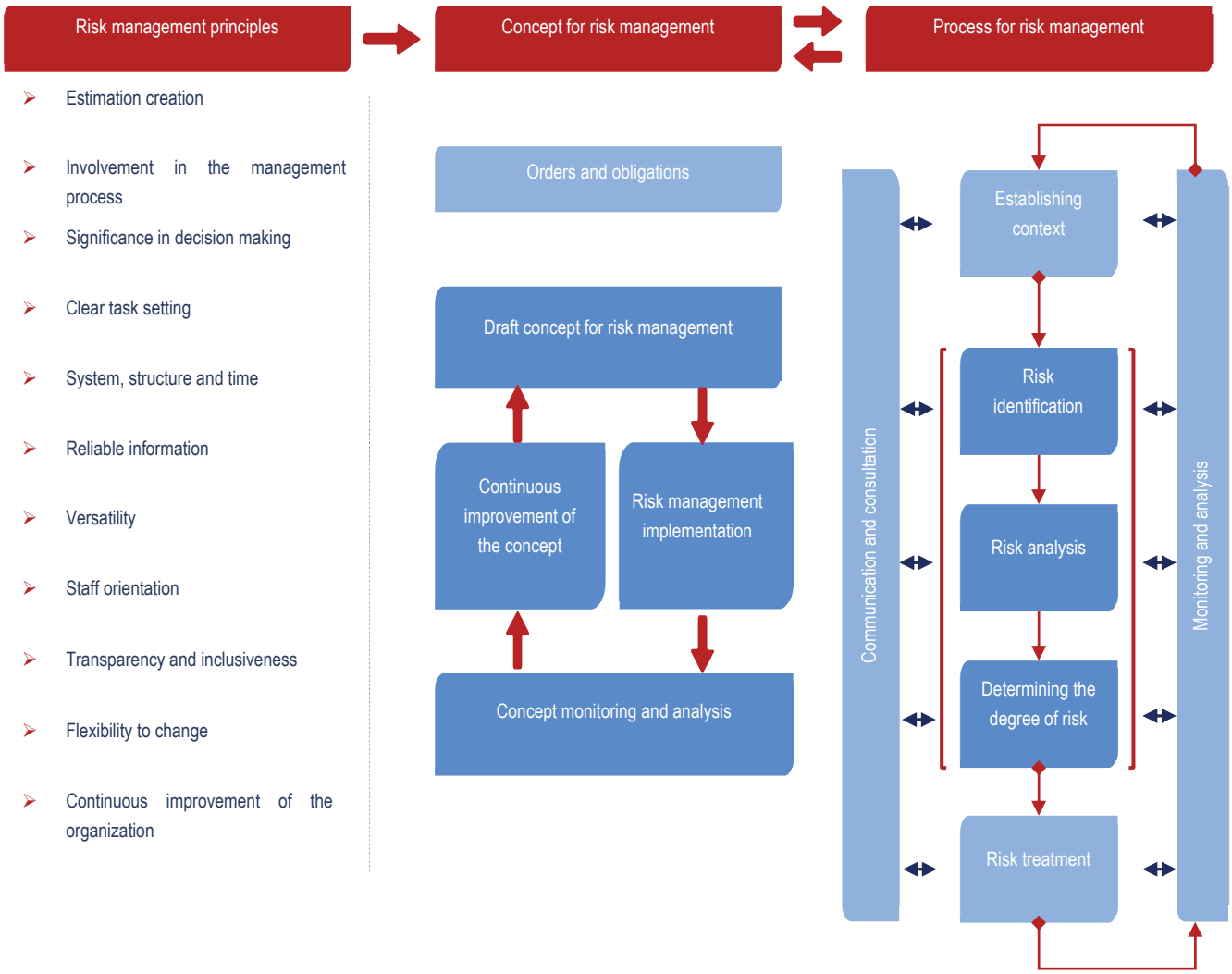

Figure 4 Enlarged diagram of risk management

As a result of calculations, we have the following:

- identification of possible dangerous situations and events in which there is a risk of exposure to hazards to the worker and determination of their causes;
- assessment of the possibility of hazardous situations and the impact of hazards on the worker's organism;
- assessing the significance (severity) of the consequences of these possible hazardous situations, if they occur, as well as the impact of hazards on the worker's organism;
- determining whether the assessed degree of risk is negligible or acceptable for the organization, in which the adoption of any additional security measures, in addition to those already applied, is not required, or unacceptable, when additional measures are required to control this unacceptable risk [14].

It should be noted that risk assessment should be performed for each identifiable parameter [15, 16].

5.1 Proposal of a Possible Concept for Risk Management at LNG Bunkering Facilities

The work is aimed at forming a strategy for risk management and staff protection through a clear drawing up of the company's priorities, requirements for installations and for protective equipment. Thus, the developed concept should reflect and contain requirements that should provide comprehensive information on planning the management process, the distribution of responsibilities between the subjects and the characteristics of hazardous and harmful substances used in the process.

The proposal for risk management is that the basic techniques and methods for risk assessment and concept preparation are proposed to be applied to each link of the bunkering process. The implementation apparatus will consist in the fact that the management process will be significantly simplified by splitting the stages of the process, analyzed in terms of risk assessment and presented as a whole unified production concept. The diagram is shown in Fig. 5.

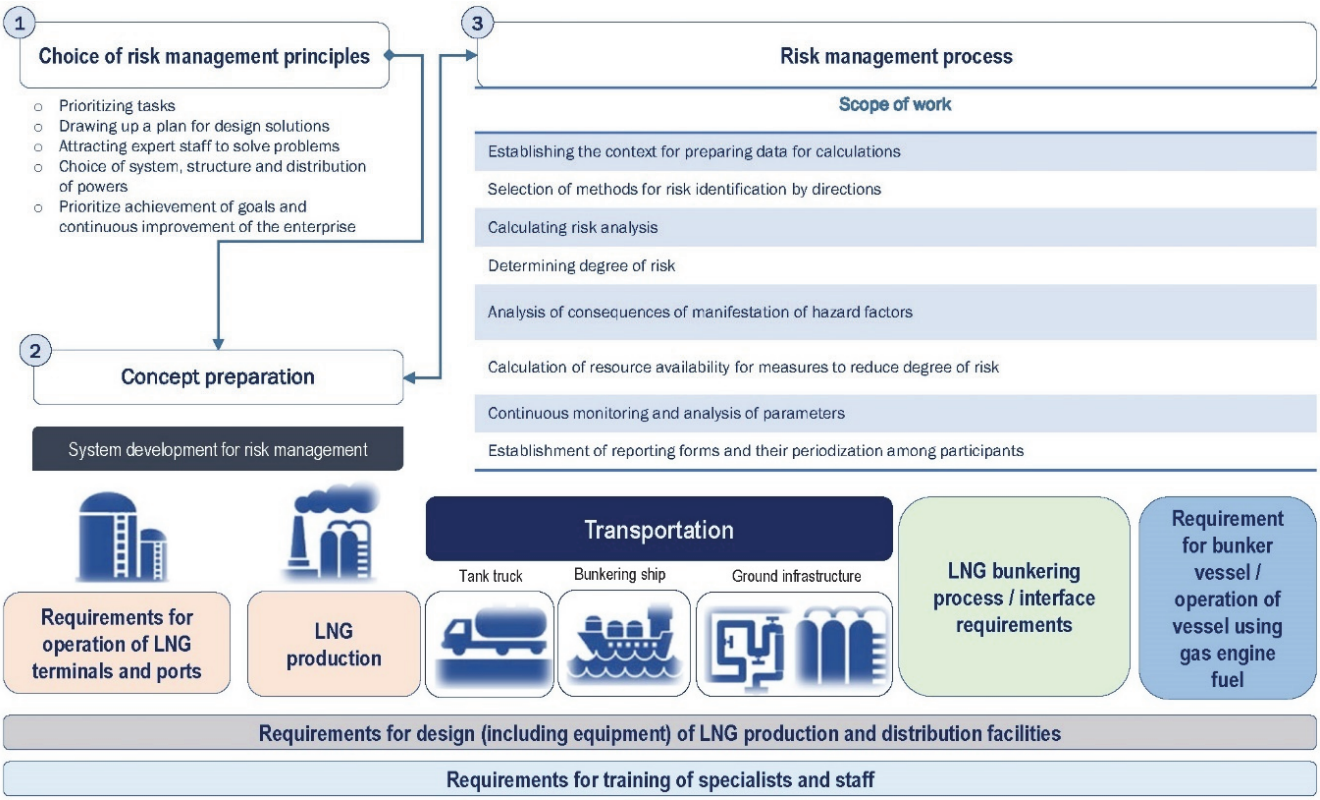

Figure 5 Proposed risk management scheme for LNG bunkering facilities

Thus, the main components of the concept will establish and consolidate areas of activity, for each of which a safety calculation is proposed. The product of the concept preparation will be the development and implementation of a risk management system, when all of them will be identified and calculated according to the most likely scenarios. The area of the management process should be constantly reviewed at all stages of management, thus it is possible to ensure the rational allocation of resources for labor protection measures. Thus, the results achieved should be revised and goals set taking into account the manifestation of new factors, or by that time new requirements will be established that regulate this or that activity.

An approximate plan for preparing a project for the implementation of the tasks set will be:

- Application area as a guide for the preparation of local regulations for natural gas liquefaction and transportation companies. The scope of practical recommendations reflects, but is not limited to the concept of a risk-based approach to the formation of a system and organization of labor protection in the field of LNG bunkering. During the development, the parameters of the development of projects in the Russian Federation were assessed, and a structural analysis in the field of risk management was carried out.
- Place of man-made risk management in the occupational safety management system. An organization that prioritizes the preservation of life and health of staff providing technological processes should be guided by an occupational safety management system. When choosing the fundamental techniques and means of ensuring safety, it is necessary to make a qualitative and quantitative assessment of the risk of production processes. By developing a risk management concept for an organization, issues related to ensuring comprehensive labor protection are being addressed. By establishing additional requirements for substances that are used in the transportation of hydrocarbons by sea, the likelihood of accidents and incidents that can lead to irreparable damage to the environment is reduced.
- Development of a risk management structure for LNG facilities. The risk management process should, on the one hand, regulate the whole system of the production and transportation process, and on the other hand, allow the calculation of each individual process. The concept should reflect all processes as a whole in terms of risk management of production, and for each process, a risk management manual should be developed and prepared. The concept preparation process is based on the deming quality management method and is a closed process that implies continual improvement.

The concept should reflect the main risks of production, establish priority tasks for their reduction and fix the basic requirements. The application of the concept should be carried out taking into account the availability of resources and rational investment in labor protection measures and implementation of safety systems. The

concept preparation process is based on calculating the risks for each complex production process in interconnection with each other and in related issues of energy transmission.

6 CONCLUSIONS

The study showed that to date, national legislation does not yet have a complete, satisfying list of technical requirements for the transportation of LNG by sea.

Due to the fact that the shipment of natural gas is planned not only for the state's own needs, but also for export, there is a need to harmonize national requirements with the requirements of international law.

The proposed guidance contains recommendations for planning the risk management process associated with the damaging factors of the manifestation of hazards, bringing the organization's own norms and standards into compliance with the requirements of foreign legislation, mechanisms for managing the quality of labor protection of the entire production process.

The developed approach is illustrated by the example of the analysis of investment projects of Gazprom.

The developed concept and the mechanism for its implementation are reflected and are practically applicable for all industrial enterprises through the development of local regulations of the organization based on a risk-based approach, which will allow making decisions based on a specific need, and their implementation will increase the level of industrial safety not only for facilities bunkering LNG, but also the fuel and energy complex as a whole.

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