Occupational Risks Management as a Basis of Industrial Injuries and Occupational Disease Prevention

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Abstract. The Government of the Russian Federation sets the task to create a new Health, Safety and Environment Management System (HSEMS) based on the implementation of procedures described as occupational risks management. The functioning of the new HSEMS model will promote turning from the practice of reacting to the already occurred facts of injuries and occupational diseases into the mechanism of the development and performing the preventive measures against accidents, and maintaining the personnel health. However, the implementation of the risk management into the health and safety activities of enterprises is constrained by the methodological difficulties in identifying measurable or estimated parameters, which are required for implementation occupational safety management processes. The recommendations for establishment of qualitative characteristics of the occupational risks assessment, methods of their turning from verbal parameters into quantitative parameters, as well as in determining the boundaries between acceptable and unacceptable risks are presented.

1. Introduction
The Government of the Russian Federation sets the task to modernize the Health, Safety and Environment Management System (HSEMS) previously established in Soviet times based on the compulsory performing the state regulation requirements, and to form a new system, an important part of which should be the actions of identifying, assessment and elimination or reduction of the hazardous and harmful production factor level [1]. In other words, a new model of the Health, Safety and Environment Management System should include the implementation of procedures characterizing as occupational risks management. Formation and implementation of the new HSEMS model allow turning from the practice of reacting to the already occurred facts of injuries or occupational diseases into the mechanism of the development and implementation of the preventive measures against accidents and for maintaining the personnel health.

The new approach to ensuring occupational safety implies that both health damage, and potential, not manifested production threats in an implicit, latent form to be recognized, assessed and minimized (or eliminated) in advance should be the subject of practical actions [2]. Practically, the direct control of the process parameters carried out under a constant condition is more effective than monitoring the results of the same process performed only at the last stage of the event. From the standpoint of occupational safety, this means certain advantages in the formation of safe labor conditions over the investigation procedures performed only after a hazardous incident has occurred. These advantages are specific to constant occupational risk management procedures. Another positive factor of the risk management system is that it makes it possible to predict the results of the process, namely, to pre-
sume with a reasonable degree of probability the dynamics of improvement or deterioration of occupational safety [3].

The activities of any organization involve risk, therefore risk management is used in all business processes. Thus, procedures for occupational risks assessment are recommended as an initial step in the development of approaches to the safety management and personnel health protection, as well as the structure of the occupational safety and health system at the enterprises. Since 1989, when the European Union adopted a framework Directive on the Introduction of measures to promote improvements in the field of personnel safety and health at work, risk assessment has become a cornerstone of the European approach to occupational safety and health [4]. Today, the occupational risk assessment is an obligatory procedure in the European Union for all employers. After Russia's accession to the World Trade Organization, this approach is recommended for our country as well. In 2011, the Federal Law make amendments and additions related to the concepts of "occupational risk" and "occupational risks management", into the Article 209 of the Labor Code of the Russian Federation.

2. Methodology
Two important points are characteristic features of the occupational risks management system. First of all, management activity is a cyclic order of performing interrelated practical actions known as the Deming-Schuhart cycle or as PDCA cycle (Fig. 1). The content of the cycle includes a set of procedures divided into several stages: Plan - Do - Check - Act. After the completion of the last stage, a new cycle of the same practical actions should be begun at the same workplaces, but with new goals and objectives for risks reduction. And, secondly, the implementation of the same cyclic procedures carries out a "process approach" in solving problems that allows providing conditions for activities to continuously improvement of working conditions, on the continuous improvement of the occupational safety management system.

![Figure 1. Scheme of the Deming-Schuhart cyclic process (PDCA cycle)](image)

It is possible to control only those processes that have measurable or estimated parameters. In the field of occupational safety, occupational hazards and injuriousness expressed through quantitative or qualitative parameters of occupational risk are taken as such parameters. Risk management means the risk recognition and analysis, the development and implementation of management decisions to reduce the possibility of adverse situations, as well as the possible material or other losses reduction. Risk management assists to get out of the uncertainty zone into a situation with more or less predictable results.

Risks are created by the hazards and injuriousnesses of the process environment, as well as by the level and intensity of the workload of the personnel. Previously, it was believed that it was necessary
to strive to create absolute safety, to prevent any negative manifestations of the process environment, but we had to back down on the concept of zero risk, because all living environment, especially in the field of material production, is accompanied by risky situations, which cannot be avoided. Today the concept of acceptable risk is used in practice, i.e. risk, which level is recognized as acceptable by state bodies, the production community, public organizations and directly by personnel [5].

Risks are an objective phenomenon in the enterprise activities. They accompany everything and all areas of its activities. Despite the fact that a number of risk parameters may depend on ambiguous actions of personnel or subjective management decisions, the objective nature of its manifestation remains intact.

The very concept of risk means a combination of two factors, namely the probability (frequency) of the damage occurrence and the level of this damage. The higher the probability of material or other damage and the greater the expected losses, the greater the risk. At the same time, risks can be the same in those cases when situations occur, for example, with the maximum probability of the damage origin and the minimum indicators of its level. Or vice versa, in case of low probability of loss with the simultaneous expectation of significant damage.

The probabilistic nature of the risk is associated with the potential manifestation of some occupational hazards and with the uncertain nature of their possible occurrence. In other words, a risky event may occur or not. The degree of this probability is determined by the action of both objective, and subjective factors, but the probabilistic nature of the risk is a constant characteristic of it. For its determination combination of different sources both as a whole and individually is used:

1) Expert assessment of the specialist. Despite the fact that risk as a phenomenon has the objective nature of origin, the assessment of the probability for its occurrence through an expert decision is subjective. This subjectivity will reflect the unevenness of this objective phenomenon assessment. It is due to the difference in the level of completeness and reliability of the information available to the expert, his qualification and experience in the field of occupational safety, and other factors as well;

2) Statistical data on injuries and occupational diseases using the frequency, severity, fatal case and disability rates, injury rate index and other data. These are so-called direct assessment methods. The reliability of determining the possibility of hazard occurrence and the onset of damage to a decisive extent will depend on the amount of available statistical information. In the quantitative incompleteness of objective data on incidents, the damage possibility assessment may reflect not a stable event, but a random process. Therefore, it is advisable to use statistical data for large enterprises or entire branches of the economy accumulating significant blocks of relevant information in their activities;

3) The method of logical analysis, known as the event tree. The event tree allows modeling hazardous processes and expressing them as causal relationships diagrams. It reflects the presence of hazards, their possible manifestations and possible health damage from each hazard;

4) The method of verbal functions. The method refers to the probable assessment methods. It is based on assumptions that are formed from subjective opinions of specialists. But at the same time it reflects the objective possibility of the undesirable event. The method based on the fact that a quantitative value of the event occurrence probability is assigned by the expert to each description of a potentially hazardous situation in the process environment. The method of verbal functions can be used along with a logical analysis of the event tree when a corresponding weighting factor is assigned to each level of damage probability.

3. Key Findings
To assess the probability or damage occurrence frequency, it is offered to use three grades formed on the basis of expert opinions [6]:

- probability is low. It reflects the situation when the detected or manifested hazard capable to cause the certain damage to an employee should not arise during the entire period of his professional activity;

- probability is average. It characterizes the situation when the certain damage of the detected or manifested hazard can occur only in certain periods of employee’s professional activity;
- probability is high. It characterizes the situation when during the entire professional activity of the employee conditions causing him some definite damage from the detected or manifested hazards can arise constantly.

The division of potential damage probability into several steps, for example, into three, makes it possible to turn this qualitative parameter into a quantitative assessment using expert opinions. This is performed by assigning the corresponding value of the weighting factors characterizing this factory world to each probability level. (Table 1) [6].

The severity of the probable risk manifestation indicates the scale of the expected negative consequences, reflects the degree of adverse outcome of the event. The damage appears itself in the form of chronic or acute occupational and production-related diseases, as well as in cases of industrial injuries.

As the damage severity parameters it is recommended to use the following qualitative parameters [6]:
- deterioration of employee health, which should be perceived as a decrease of his/her professional qualities. The World Health Organization (WHO) considers the health to be the state of the person's complete physical, mental and social well-being, but not only the absence of disease or physical handicaps;
- functional disorder of the body. Any work activity is accompanied by changes in the nervous, cardiovascular and respiratory systems, in metabolic processes, etc. At the same time, the cerebrospinal nervous system plays a crucial role ensuring the coordination of functional changes against the background of physical and psychological fatigue;
- reduction of the forthcoming lifetime. The parameter is significantly affected by the presence and level of harmful and hazardous production factors, the severity and intensity of the working process;
- psychosocial well-being disorder expressed by dissatisfaction with work, family situation, income level, health status, etc.

| Probability | Weighting Factor | Verbal description of hazard manifestation probabilities and damage occurrence |
|-------------|-----------------|--------------------------------------------------------------------------------|
| Low         | 1               | Hazard or its manifestations, which can cause certain damage, should not occur during the entire period of the employee's professional activity. |
| Average     | 3               | Hazard or its manifestations, which can cause certain damage, occur during definite periods of the employee's professional activity. |
| High        | 7               | Hazard or its manifestations, which can cause certain damage, occur constantly during the entire period of the employee's professional activity. |

| Damage severity | Weighting Factor | Verbal damage description |
|-----------------|-----------------|---------------------------|
| Low             | 5               | The injured worker is not required to provide medical assistance; absence from work during 3 days is permitted in the worst case. |
| Average         | 10              | The injured worker is taken to the public health organization or office visit is required; absence from work during 30 days is permitted; development of chronic disease. |
| Serious         | 15              | Accident causes serious (untreatable) health damage; hospital service is required; absence from work during more than 30 days is permitted; persistent loss of earning capacity or death. |
A qualitative assessment of the damage level involves the possibility of its proceeding to the rank of a quantitative parameter. It is offered to use a special multi-level scale with the appropriate weighting factors are established for each level by an expert decision. This is the so-called indirect method of quantitative estimation of the consequence seriousness. In this case, the absolute value of the factors may be different, only the relative correlation between the values of the weighting factors has a substantial significance (Table 2) [6].

Such methods of proceeding qualitative event parameters into quantitative parameters are simple and obvious for experts, who are most often the direct work supervisors, entry and middle managers. The disadvantage of the verbal functions method is its subjectivity, which is due to the difference of individual qualities of each specialist in relation to professional knowledge, experience, etc., and which provokes the appearance of some error in the assessment of the situation. However, the collective decision of the expert group allows leveling the personal characteristics of specialists and developing an assessment that is as close as possible to be objective.

It is necessary to implement the concept of acceptable risk in order the occupational risk assessment is carried out precisely by measurable quantitative parameters, which would make it possible to compare them with that level of hazards which quantitative characteristics are recognized as acceptable. There are various ways to quantify risks, based on statistical, expert statistical and expert methods of processing information. The correctness of their use depends on the block of recorded facts of adverse events, for example, for a large number of registrations (one thousand or more) that can be generated in large enterprises. It is recommended to use statistical assessment methods. At the same time, for a small enterprise or specific workplace, the volume of such observations is unlikely to exceed 100 units. Therefore, the most preferable method is the method of expert assessments for the scale "workplace - small production".

In developed countries, a method based on the probability-damage matrix is often used for direct quantitative risk assessment [7]. The content of the method is that the expert or experts describe the content and rank the probability of damage for each situation, for example, on a three-level scale - the probability is low, the probability is average and the probability is high, and the potential damage level corresponding to this situation, for example, on a three-level scale as well - the damage is low, the damage is average and the damage is serious (Table 3).

Table 3. The occupational risk magnitude quantification

| The damage severity and the weighting factor magnitude | The risk magnitude with probability (frequency) and weighting factor of the damage occurrence |
|-------------------------------------------------------|------------------------------------------------------------------------------------------|
| Low - 0.3                                             | 0.1                                                                                     |
|                                                      | Average - 0.7                                                                          |
|                                                      | 0.2                                                                                     |
|                                                      | High - 1.0                                                                             |
|                                                      | 0.3                                                                                     |
| Average - 0.7                                         | 0.2                                                                                     |
|                                                      | 0.5                                                                                     |
|                                                      | 0.7                                                                                     |
| Serious - 1.0                                         | 0.3                                                                                     |
|                                                      | 0.7                                                                                     |
|                                                      | 1.0                                                                                     |

The weighting factors of damage level and the probability of damage occurrence are offered to be 0.3; 0.7 and 1.0 respectively. At the intersection of a particular column and line is the desired relative risk magnitude. It is obtained by multiplying the weighting factors of the damage level and the probability of the event and expresses the quantitative interpretation of the occupational risk magnitude.

Another simple and illustrative way to quantitative assessment risk is the methodology developed at the Finnish Institute for Occupational Health and at the Occupational Safety and Hazard Administration of the Ministry of Social Affairs and Health of Finland and called the Elmery system [8]. The method is based on observing the actual working conditions at work and comparing them with the legislative and regulatory requirements for health and safety procedures. Assessment criteria are de-
veloped and verbally described for each direction. They contain the normative documents requirements, and reflect the subjective opinions of specialists in the appreciation of the situation as well. The work results are recorded in special questionnaires, where the positive moments are placed in the "good column", and the negative ones are placed in the in the "bad" column. After the assessment, the "good" and "bad" moments are counted and a relative parameter, namely the Elmery index is figured characterizing the safety level of the observed site.

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\text{Elmery Index} = \frac{\text{points "good"}}{\text{points "good" + points "bad"}} \times 100\%
\]

The value of the index is in the range from 0 to 100%, the result obtained, for example, 60% means that 60 points of the questionnaire out of 100 meets the safety requirements, and 40 points of the observation results had deviations.

A practical guide on risk assessment at work issued by the International Labor Organization provides recommendations for determining the risks significance, i.e. by defining the boundary between an acceptable and unacceptable risk magnitude [9]. To determine the risks magnitude one of the methods applied in the British standard BS 8800 is used. In accordance with it, it is set out and described the content of the three levels of damage occurrence probability: remote, average and high, and three levels of damage consequences, namely negligible, moderately significant and serious (Table 4). The risk magnitudes differ from the minimum value 1 - minor risk, up to the maximum value - 5 as unacceptable.

| Probability  | Negligible | Moderate significant | Serious       |
|--------------|------------|----------------------|---------------|
| Remote       | 1 – Minor risk | 2 - Low Risk         | 3 – Moderate risk |
| Average      | 2 - Low Risk   | 3 - Moderate risk    | 4 – Significant risk |
| High         | 3 – Moderate risk | 4 - Significant risk | 5 – Unacceptable risk |

The decision on what the risk level is considered acceptable and what is unacceptable depends on the goals set by the organization management, as well as on the availability of appropriate resources for measures implementation to improve occupational safety and health. It is reasonable to separate low risks and factor them out of the planned actions, and to identify the greatest risks from the point of view of occupational safety and focus on the significant problem issues that must be solved first. Such approach to improving the safety at work makes it possible to timely solve the most priority tasks of occupational safety, and on the other hand, to ensure the continuity of the process to minimize the hazard consequences.

An approximate boundary of the risk division, which the decision to carry out occupational safety and health measures depend on, can be the difference in the risks magnitude according to the risk table (Table 4). If the risk magnitude is 1 or 2, which means a minor or low risk, then its level can be recognized as acceptable and do not plan practical actions for its reduction. If the risk magnitude is 3, 4 or 5 (respectively moderate, significant and unacceptable), then the risks should be considered unacceptable and they must be minimized with different degree of urgency. Naturally, the priority actions in the planning documents should be actions to reduce or eliminate high-risk levels (Table 5), as recommended by the ILO practical guide.
Table 5. Recommendations on the priority and necessity for measures implementation

| Risk magnitude | Necessary measures for risk reduction |
|----------------|---------------------------------------|
| Minor risk     | The risk is so low that no measures to improve occupational safety are required. |
| Low risk       | Measures to improve occupational safety are not necessary, but the situation must be monitored so that the risk shall not turn into an uncontrolled state. |
| Moderate risk  | Carrying out measures to reduce the risk is necessary, but their implementation can be carried out in accordance with the planned work schedule. If the risk causes serious consequences, it is necessary to find out the probability of the accident more precisely. |
| Significant risk | Risk reduction measures are mandatory and they must be started immediately. Risk-based work should be immediately finished, and it must not be continued before the risk is reduced. |
| Unacceptable risk | Risk abolishment measures are mandatory and they must be started immediately. Risk-based work should be immediately finished, and it must not be continued before the risk is abolished. |

4. Conclusion

The method of professional risk management is based on the implementation of the concept of "acceptable risk". It implies that each organization has the right to establish its own limit of acceptable or unacceptable level of danger in the workplace. In practice, risk assessment is provided by direct work managers, middle and lower managers who do not have deep theoretical knowledge. Therefore, it is especially important for them to have such methods of measuring risk parameters that allow, on the one hand, to use simple and clear procedures, and, on the other hand, to get a fairly objective picture of working condition.

The review of the methods of occupational risk assessment shows that the applied technologies make it possible to form an adequate understanding of the magnitude of industrial hazards acceptable to the enterprise. For this purpose on the basis of expert estimates direct managers of works at first formulate qualitative parameters of measurement of probability and severity of a negative event, and then by means of the established weight coefficients translate them into quantitative parameters of risk assessment. Thus, applying the "process approach" in occupational safety through the implementation of the" Deming-Shuhart cycle", the company receives measurable indicators of changes that occur in the workplace at the end of the next cycle. This is the essence of professional risk management, which enables the company to formulate the degree of need for practical actions to improve working conditions, as well as to establish the priority of their implementation.

Reference

[1] Golikova T A About the Measures Aimed to Improve Labor Conditions, Preserve Employees Life and Health. Report made at the Meeting of the Russian Government on October 27, 2011. Health and Safety and Accidents Prevention in Construction Industry. No 1, 2012, p. 7-11.
[2] Sugak E B Nature of occupational accidents in the aspect of occupational risks management - Life Safety - No 7, 2015, p. 3-6.
[3] Fedorets A G Management of industrial safety and risk assessment. Collection of articles. - M., ANO "IBT", 2012 - 152 p.
[4] R A Litvinov. Forming Health and Safety Management Systems. Trends at the International Level Health and Safety and Accidents Prevention in Construction Industry. No 4, 2013, p. 12-18.
[5] Sugak E B About Health and Safety Contemporary Models . Collection of abstracts of the International Scientific Conference entitled “Integration, Partnership and Innovations in Construction Science and Education”. Moscow, MSCU, 2013, p. 185-186.
[6] Russian National Standard 12.0.010-2009 Occupational safety standards system. Occupational safety and health management systems. Risk identification and risk assessment.

[7] Fedorets A G Methodological bases of quantitative assessment of occupational risks - Energy security in documents and facts - No 2, 2008, p. 10-16.

[8] Manual for the working conditions control at work in the industry. The Elmeri-Helsinki system - the Finnish Institute for Occupational Health, the Department of Labor Protection under the Ministry of Social Affairs and Health of Finland - 2000, p. 24.

[9] Murtonen M Risk assessment at work - A practical guide. - M., Subregional ILO Office for Eastern Europe and Central Asia. - 2007, p.69.