Development and Implementation of Methods for Behavioral Safety Audit Conducting in the Fuel and Energy Complex

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Abstract. The analysis of the accident and industrial injury statistics shows that the majority of accidents and industrial accidents (more than 70%) are caused by the mistakes of the operational personnel servicing the hazardous production facilities connected with violation of requirements of the organization and production of hazardous works. One of the priority directions of the state policy of the Russian Federation in the field of industrial safety till 2025 is the development of industrial safety culture, awareness of personal responsibility for a condition of industrial safety, formation of the intolerant relation to violations of safety requirements, in particular, due to implementation of scientific and technical achievements and the best practices. This study proposed a new approach to ensuring safety on objects of fuel and energy complex establishing rules of conducting the behavioral safety audit (BSA), assessment of identified hazardous actions and use of preventive measures. Within approbation of this new approach to safety ensuring we have made the procedure of mathematical processing of results of 264 conducted BSA on one of gas transmission companies. Implementation of approach boosts safety culture of production, prevention of the industrial accidents and accidents caused by unsafe behaviour and actions of workers.

1. Introduction

According to the International Labour Organization statistics, about 2.3 million people in the world die every year as a result of industrial accidents and occupational diseases. The scale of consequences costs to the global economy 3 trillion dollars that make 10-15% of world GDP [1]. According to data of Federal Service for Environmental, Technological and Nuclear Supervision (Rostekhnadzor) for the last 5 years, we can conclude that the accident rate and occupational injuries on hazardous production facilities of oil and gas complex are at a rather high level [2-6].

The analysis of statistical data of accident rate and occupational injuries allows claiming that more than 70% of accidents and injuries are caused by a human factor [7-12]. Developed regulatory legal acts and technical documentation in the field of safety do not always provide necessary positive effect as safety on production is connected, first of all, with professional competences of employees, existence of motivation to safe performance of work, safety culture. The major role in formation of a safety culture plays a style of the organization management (leadership) and clear demonstration of their responsible attitude to issues of industrial safety and labor protection [13]. For this reason, one of the priority directions of state policy of the Russian Federation in the field of industrial safety till 2025 is the development of a culture of industrial safety, awareness of personal responsibility for a
condition of industrial safety, formation of the intolerant relation to violations of safety requirements [14]. The important principle of realization of this policy is implementation of scientific and technical achievements and the best practices for ensuring industrial safety [14]. Therefore studying the best international practices in this field is of definite scientific and practical interest.

2. Relevance

Currently, foreign companies widely use the method of evaluating the safe behavior of workers - behavioral safety audit (BSA), which assumes manager’s supervising of employees’ actions during the work process and also the subsequent conversation with the analysis of safe or hazardous behaviour models. This approach allows setting the correct model of employee’s behaviour, to adjust his actions as well as to estimate efficiency of activities for ensuring industrial safety and labour protection [15-19].

In 2009 17 separate studies on the efficiency of implementation of the specified method in the United States of America and in a number of the European countries, in which more than 25000 employees of 24 enterprises of metallurgy, construction, oil and gas production, and other industries took part, were conducted [20]. According to the results of work, it is stated that “The behavioral safety processes positively affect behavior and reduce incident rates in companies” [20]. According to [20], the main components of an ideal process of behavioral safety are: identification of unsafe behavior; development of appropriate observation checklists; training (both of observers and auditors); safety assessment by making observation; providing feedback (verbally in the course of communication and also graphically – by results of the report).

BSA is also implemented in many Russian enterprises. Based on the results of the comparative analysis of implementation of this approach in five companies (PJSC “NK “Rosneft”, JSC “Russian Railways”, PJSC “Gazprom Neft”, PJSC “MMC “Norilsk Nickel” and PJSC “Sibur Holding”) the conclusion was drawn on similarity of the basic principles of BSA conducting and difference of report forms – the document where all revealed violations, proposals on prevention of their recurrence, as well as corrective actions by the auditor and the company management, are specified. The main element of the report is the categories of observation, which help to estimate both actions of employees and conditions in their workplace. They allow defining risk, focusing attention on those moments, which lead to the most frequently occurring hazards/hazardous events. Thus, establishing the categories of observation for implementation of the method of evaluating the safe behavior of workers is a relevant task.

3. Development of method for behavioral safety audit conducting

In this study, we have proposed the following categories of observation: reaction of employee/employees, actions of employee/employees, workwear and PPE, tool and equipment, instructions and rules, workplace, transport. For each category of observation, audit criteria were developed in number from 3 to 12. The BSA report form, including the above-stated categories of observation and criteria of audit, is presented in figure 1.

The description of the employee’s actions or conditions at his workplace by observable categories should be evaluated in terms of compliance by one of two indicators:

- “Dangerous” – in case, when the observed criteria (condition/action) corresponds to the statement in BSA form, that is, it represents a hazard, creates prerequisites for a hazardous event;
- “Not applicable” - in case, when the criteria (condition/action) is not observed/is absent (because of specifics of performance of work or features of technological process).

If the observed criteria (condition/action) does not correspond to the statement in the form, it means that it does not constitute a hazard, does not create the prerequisites of a hazardous event and is not fixed in BSA form.
### Figure 1. BSA Results Report.

The necessary comments are recorded at the discretion of the auditor in the “Other” section in the process of observation.
The main findings of the audit in the form of planned actions to prevent an accident or to encourage safe performance of work, indicating the responsible and deadlines, are recorded in the “Measures taken to eliminate and prevent deficiencies” section. If it is necessary to take long-term corrective actions to eliminate the comments, they should be discussed with the immediate supervisor of an employee.

Conducting BSA with a filling of the report gives the grounds for drawing conclusions based on the results of audit/audits. According to BSA results, it is not allowed to punish workers.

For analytical assessment of the conducted audits results, we have proposed calculation of the following indicators:

- Compliance with audit schedule (S)
  \[ S = \frac{A_p}{A_s} \cdot 100\% \]
  \[ (1) \]
  where \( A_p \) – number of audits performed; \( A_s \) – number of audits scheduled.

- The number of managers who do not participate in BSA or do not follow the schedule of the planned BSA (\( N_p \))
  \[ N_p = \frac{N_n}{N_t} \cdot 100\% \]
  \[ (2) \]
  where \( N_n \) – the number of managers who did not fulfill the audit plan; \( N_t \) – total number of managers.

- Hazard indicator of one audit conducted (\( N_i \)). The indicator is calculated on the total number (40) criteria of observed categories:
  \[ N_i = \frac{K_d}{40 - K_{na}} \cdot 100\% \]
  \[ (3) \]
  where \( K_d \) – the number of identified criteria with the indicator “dangerous”; \( K_{na} \) – the number of identified criteria with the indicator “not applicable”.

- Hazard indicator of all audits conducted for the chosen (\( i \)) period (\( N_a \)).
  \[ N_a = \frac{\sum N_i}{A_t} \]
  \[ (4) \]
  where \( N_i \) – hazard indicator of one audit conducted; \( A_t \) – total number of the conducted audits for the chosen (\( i \)) period.

For analytical assessment of the received values, their graphical representation in the form of radar charts consisting of two stages is recommended.

At the first stage it is necessary to calculate the hazard indicator of the observed category by the results of one conducted audit (\( N_{it} \)) for each of observed categories on equation (5).

\[ N_{it} = \frac{K_{id}}{n - K_{ina}} \cdot 100\% \]
\[ (5) \]
where \( i \) – serial number of category; \( n \) – the number of category criteria; \( K_{id} \) – the number of identified criteria category with the indicator “dangerous”; \( K_{na} \) – the number of identified criteria category with the indicator “not applicable”.

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- Hazard indicator of all audits conducted for the chosen (\( i \)) period (\( N_a \)).
  \[ N_a = \frac{\sum N_i}{A_t} \]
  \[ (4) \]
  where \( N_i \) – hazard indicator of one audit conducted; \( A_t \) – total number of the conducted audits for the chosen (\( i \)) period.

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\[ N_{it} = \frac{K_{id}}{n - K_{ina}} \cdot 100\% \]
\[ (5) \]
where \( i \) – serial number of category; \( n \) – the number of category criteria; \( K_{id} \) – the number of identified criteria category with the indicator “dangerous”; \( K_{na} \) – the number of identified criteria category with the indicator “not applicable”.

\[ \]
At the second stage on an equation (6) it is necessary to calculate the hazard indicator of the observed category by the results of all audits with employees of division \( N_{ia} \), which represents average value of an indicator \( N_{ia} \) for each of observed categories.

\[
N_{ia} = \frac{\sum N_{il}}{l},
\]

where \( i \) – serial number of category; \( l \) – the number of audits conducted with employees of the division for the reporting period; \( N_{il} \) – hazard indicator of the observed category by the results of one conducted audit.

4. Experimental results

In this research, 264 audits were conducted in 14 branches of the gas transmission company using the developed method. The received results differ significantly depending on the branch. As an example, the constructed charts of the hazard indicator of the observed category based on the results of all audits with employees of division \( N_{ia} \) in branch No. 8 and branch No. 12 are illustrated in figures 2 and 3.

**Figure 2.** The radar chart of an \( N_{ia} \) indicator in branch No. 8 of gas transmission company.

**Figure 3.** The radar chart of an \( N_{ia} \) indicator in branch No. 12 of gas transmission company.

In the analysis of the radar chart of branch No. 8 it is possible to draw a conclusion that the highest value of an \( N_{ia} \) indicator is accepted by categories “Reaction of employee/employees” (88.1%) and “Actions of employee/employees” (95.1%) while in branch No. 12 categories “Workwear and PPE” (88.9%) and “Instructions and rules” (100%) are the most hazardous. At the same time, the minimum value of an \( N_{ia} \) indicator in both branches is fixed on category “Transport” (0% and 3.6% respectively). The differences can be explained by the specifics of the activities of the branches and the safety culture that has formed there. For employees of branch No. 8, as a rule, less contacting in the production process with the management, it was unusual to continue work at appearance of the auditor that affected their reaction. During audit there were also found significant discrepancies in correctness of their actions in terms of safety – they worked in an inconvenient pose, hurried and did not protect themselves from the available hazards.

When conducting audits at branch No. 12, it was found that workers used PPE with a high degree of wear and tear, and, besides, not always used PPE correspond to the type of the work performed. At an examination of workers of requirements of instructions and rules, it was revealed that employees of branch No. 12 are not always ready to answer the questions of the auditor. It is directly connected with
the insufficient attention of the management of branch to issues of training of workers and development of their competences.

Similarly, we have constructed the radar chart of an $N_{ia}$ indicator by results of all 264 audits for the gas transmission company (figure 4).

![Figure 4. The radar chart of an $N_{ia}$ indicator in the studied gas transmission company.](image)

When analyzing the data obtained, it can be concluded that all observable categories, with the exception of “Transport”, have a similar hazard indicator (average $N_{ia} = 61.8\%$), which is at an average level. The management of the company should pay attention to these results in order to avoid accidents and fatal accidents, take necessary measures to increase in level of a safety culture of staff.

Constant conducting BSA allows defining the “Alarm area” of a particular site, division, or branch of a company. The “Alarm area” is built on the basis of the collected statistics of the values of the hazard indicator for the selected period and is depicted as segments on the graph axes representing the observation categories. The intersection of the established “Alarm area” with the calculated area following the results of audits may be a signal of the presence of prerequisites for an incident. The “Alarm area” should be determined by the company management based on the current injury situation for a specific facility. It is supposed that the company strives to achieve a “Zero alarm area” in the process of its activities.

5. Conclusion

Within carried research, the new approach to ensuring safety establishing rules of conducting the behavioral safety audit, assessment of identified hazardous actions and use of preventive measures is developed.

We have proposed the procedure of mathematical processing of results of conducted BSA, which allows both defining the hazard indicator of one or several audits conducted and calculating the hazard indicator of the observed category.

The results of the processing of 264 conducted audits reports received during approbation of developed approach show to which of the observation categories the priority should be given at the current level of safety culture. Based on these results, it is necessary to plan and develop corrective measures for occupational safety to reduce the number of violations by category, thus, ensuring risk management in the system of industrial safety and labor protection management.
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