# LABOR PROTECTION

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## Assessment of industrial injuries on the example of operating Russian Nuclear Power Plants

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***Introduction.*** The article considers the industrial injuries of personnel working in the Rosenergoatom (energy division of the Rosatom State Corporation) and employees of contracting organizations working on the NPP's territory using the statistical method in the period from 2013 to 2020. Based on the data obtained, the recommendations are proposed to reduce the level of industrial injuries for the personnel of contracting organizations.
***Problem Statement.*** The purpose of this study is to research the industrial injuries and to develop recommendations for reducing injuries with personnel who work on the NPP's territory.
***Theoretical Part.*** Annual reports of Rosenergoatom are used as basic information.
***Conclusions.*** The results of the analysis indicate a significant level of industrial injuries among the employees of contracting organizations. This fact requires the implementation of a set of measures aimed at improving the safety level on the NPP's territory to prevent occupational injuries.

***Keywords:*** nuclear power engineering, contracting organizations, industrial injuries, accident analysis.

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**Introduction.** Due to the widespread use of nuclear power and the increasing number of commissioned nuclear power plants in the world, the problem of improving working conditions and reducing occupational injuries at nuclear power plants (NPP) is becoming more and more important every year.

In the territory of the Russian Federation over the past eight years, the number of commissioned power units has increased by nine, which implies an increase in the number of NPP personnel and contractor employees servicing them. In addition, the construction of new power units continues, which makes the problem even more urgent.

At the forum-dialogue "Day of Safety of Nuclear Energy and Industry", held in May 2019 in the Russian Federation, the head of Rosatom State Corporation noted that in the Russian nuclear industry there are fewer cases of injuries and deviations in the operation of equipment and the main guarantee of safety remains strict observance of discipline and strict adherence to the norms and rules of occupational health and safety at work. At the same time, for example, in 2018, several dozen cases of injuries, including fatal ones, were recorded in the industry.

The situation with industrial injuries is complicated by the constant presence on the territory of the NPP of employees of contractors who perform construction, installation and commissioning work associated with increased risks.

Injuries among employees of contracting organizations is one of the new problems that arose relatively recently, about 10 years ago, in large companies, especially mining and processing companies, after they began to launch public offerings of securities on well-known exchanges (for example, Initial Public Offering, or IPO) and in this regard had to optimize the number of employees, since a large staff prevents the establishment of a high market valuation of the company. It was the staff of auxiliary maintenance and repair services that fell under the reduction.

According to some reports, previously the share of this staff had been about 20% of the total number of employees of companies, after the reorganization they did not remain at all.

In addition, currently large companies, especially with a share of foreign capital, do not use the frequency coefficient as the main indicator of injuries, as was previously accepted, but the indicator, which is often used in world practice — LTIFR (Lost Time Injury Frequency Rate), which takes into account the actual time worked in the organization for the reporting year. This makes it possible for enterprises and organizations to improve their performance in the field of occupational safety, since LTIFR takes into account injuries only with its own personnel, while auxiliary maintenance and repair services are outsourced, outstaffed, on the commercial basis of contractual relations or in affiliated dependent companies.

The analysis of scientific papers on the issue under study allowed us to find several works devoted to similar topics in related industries, in particular in the fuel and energy complex and electric power industry [1-6], and almost the only article in which the authors proposed a methodology for predicting the number of cases of injuries and occupational diseases in nuclear power workers [7]. This situation confirms the relevance of the study and indicates the need for closer attention to the accounting and analysis of occupational injuries for this industry.

**Problem Statement.** The objective of this study is to analyze the cases of occupational injuries of personnel working on the territory of the NPP, and to develop recommendations for reducing their number.

Since the Federal State Statistics Service (Rosstat) reflects the number of occupational injuries cases in the nuclear power industry only directly from employees of nuclear power plants, the data on injuries of employees of contracting organizations are not reflected in official reports, which significantly distort the idea of the true number of accidents occurring at nuclear power plants [8]. This, in turn, reduces the quality of measures taken to prevent such cases at nuclear power facilities. In order to eliminate this shortcoming, this article analyzes cases of occupational injuries with NPP employees and the employees of contractors at nuclear power facilities in the period from 2013 to 2020, the Corporation provides such statistics in its annual reports [9].

**Theoretical Part.** ROSATOM State Corporation is a state-owned joint-stock company that unites more than 400 enterprises of the Russian nuclear industry: nuclear weapons complex, nuclear icebreaking fleet, scientific complex, nuclear medicine, handling of uranium throughout its life cycle and much more. The authors have taken for consideration the energy division of the Rosatom State Corporation, namely Rosenergoatom Concern — the only operator of nuclear power plants in Russia.

Table 1 presents data on the absolute number of accidents involving NPP employees and contractors at the corporation's nuclear power plants for 2013-2020 [10–17].

During the study period, 83 accidents occurred at NPP enterprises, among which 15 cases (18%) occurred with NPP employees and 68 cases (82%) — with the employees of contracting organizations.

Table 1

Number of accidents at Russian nuclear power plants in 2013-2020

| **NPP name** | **Years** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Balakovo | | 3 (1 c) | | | 2 | | | 1c |
| Beloyarsk | 5 (1 c) | 3 (1 c) | 1 | 1 | | | | |
| Bilibino | | | | | | | | |
| Kalinin | 1 | 2 | | 3 (1 c) | | 1 c | | |
| Kola | | | | 1 | 3 | 1 | | 2 |
| Kursk | 2 | 1 c | 1 | 1 c | 1 | 2 | 2 (1 c) | 1 c |
| Leningrad | 6 (1 c) | 1c | | | 3 (2 c) | | 4 (1 c) | |
| Novovoronezh | 2 (1 c) | 3 (2 c) | 2 c | | 1 c | 1 | | |
| Rostov | 2 | 1 c | 3 (1 c) | 3 (1 c) | | 3 | | |
| Smolensk | 2 | | | 1 | | 2 (1 c) | | |
| Floating nuclear NPP | | | | | | | 2 | |

Note: "c" – fatal accident, 5 (1 c) means 5 accidents, among which 1 accident is fatal

It is worth noting that out of 83 recorded cases, 25 cases of industrial injuries were followed by death, and among them only two cases occurred with employees of nuclear power plants, and 23 cases — with the employees of contracting organizations (8 and 92%, respectively).

During the period under study, a slight positive trend in the reduction of occupational injuries at nuclear power facilities is noticeable; the number of accidents with a fatal outcome also decreases slightly, but for the period from 2018 to 2020 it remains unchanged (two cases per year). This fact requires the analysis of traumatic factors and causes of accidents for more thorough work to eliminate the root causes of accidents (Fig. 1).

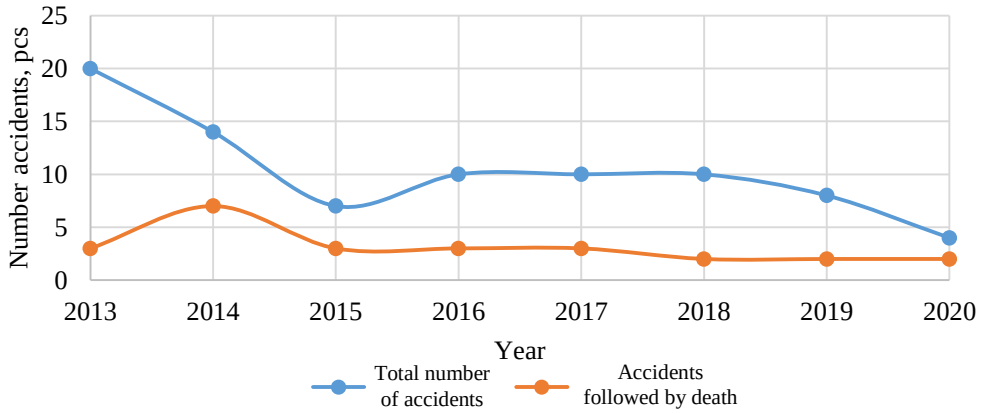


Fig. 1. Dynamics of the decrease in the number of accidents at nuclear power plants for the period from 2013 to 2020

For a more objective analysis of the level of injuries at Russian nuclear power plants, the relative indicator LTIFR was used. The data in Table 2 reflect changes in the LTIFR indicator in the Rosenergoatom concern for the period from 2013 to 2020.

Table 2

The frequency coefficient of injuries with temporary disability (LTIFR)

| **Years** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
|---|---|---|---|---|---|---|---|---|
| LTIFR Indicator | 0,025 | 0,02 | 0,02 | 0,065 | 0,03 | 0,08 | 0,04 | 0,03 |

According to this indicator, there is also no particular dynamics of improvement in the situation, in general, it is stable, with the exception of 2016 and 2018. For Rosatom Corporation, the established limit of the LTIFR indicator is 0.15, so we can assume that in general the indicators are small.

The analysis of accidents on traumatic factors shows that the vast majority of accidents occur due to the fall from a height (34%), the collapse of objects and materials (16%), the impact of rotating, moving and flying objects (14%), as a result of road accidents (11%) (Fig. 2).

Moreover, among these traumatic factors, the share of accidents with the participation of employees of contractor organizations is 93% — when falling from a height, 92% — when objects and materials collapse and because of the impact of rotating, moving and flying objects, and 67% — in an accident.

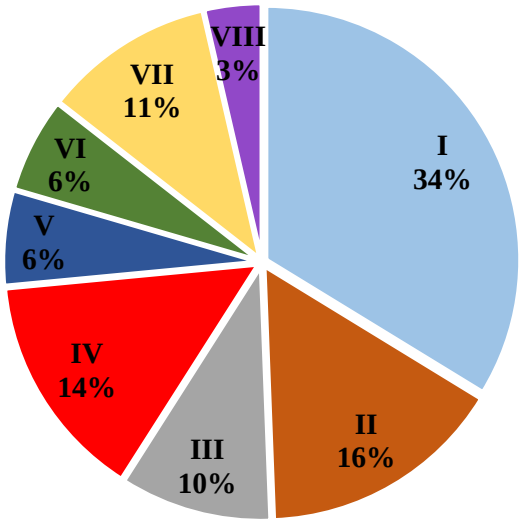


Fig. 2. Distribution of accidents by traumatic factors for the period from 2013 to 2020:
I – fall from a height, II – collapses of objects, materials, III – falling from a man's height, IV – impact of moving, flying, rotating objects, V – thermal burn, VI – electric shock, VII – accident, VIII – other

The analysis of the causes of accidents at nuclear power plants shows that out of 83 cases, the most common causes of occupational injuries for the period from 2013 to 2020 were organizational ones (80%, among them 89% occurred with employees of contracting organizations). Most often, the organizational reasons for occupational injuries are unsatisfactory organization of work, weak control over personnel, shortcomings in the organization of safe work and violation of labor discipline. In addition, personal negligence of victims is often found among the causes of accidents (28%, of which 78% occurred with the employees of contracting organizations).

The analysis of the professions of victims of accidents at nuclear power plants shows that the most susceptible to injuries professions are:

— installers (25% of the total number of accidents, all the victims are employees of contractors), and 57% of the total number of injuries with installers are fatal injuries;

— locksmiths (15%), 83% of them are the employees of contracting organizations;

— drivers, machinists (10%), 75% of them are the employees of contracting organizations;

— rebar workers (8%), all employees of contractors (Fig. 3).

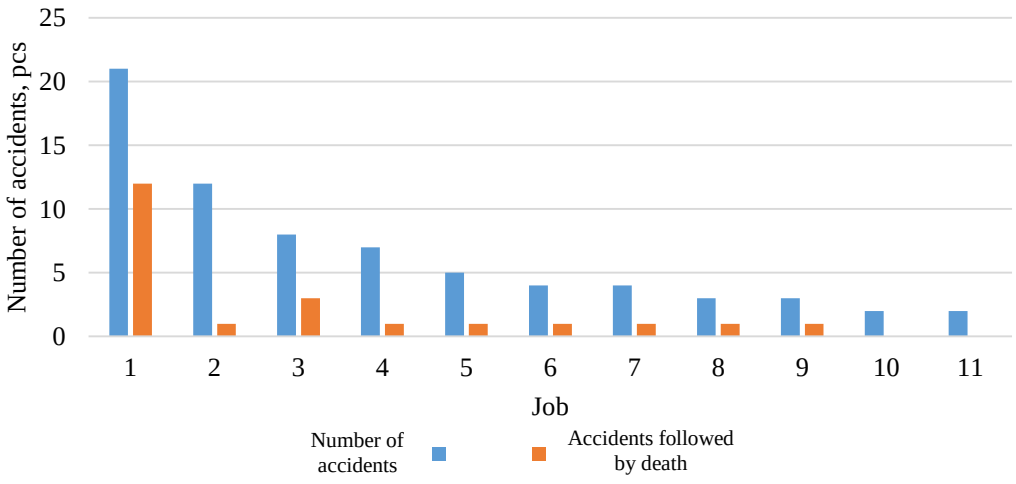


Fig. 3. Distribution of victims by profession for the period from 2013 to 2020:
1 – installers, 2 – locksmiths, 3 – drivers, machinists, 4 – rebarers, 5 – welders, 6 – electricians, 7 – specialists, engineers, 8 – insulators, 9 – concrete workers, 10 – painters-plasterers, 11 – auxiliary workers, cleaners

The most traumatic months at Russian nuclear power plants are March and June (13 accidents each), January and August (9 accidents each), which is due to an increase in repair work in the period from March to September due to scheduled preventive maintenance, major repairs and medium repairs of NPP power units (Fig. 4).

The most traumatic month in terms of fatal accidents is June (30% of all fatal accidents).

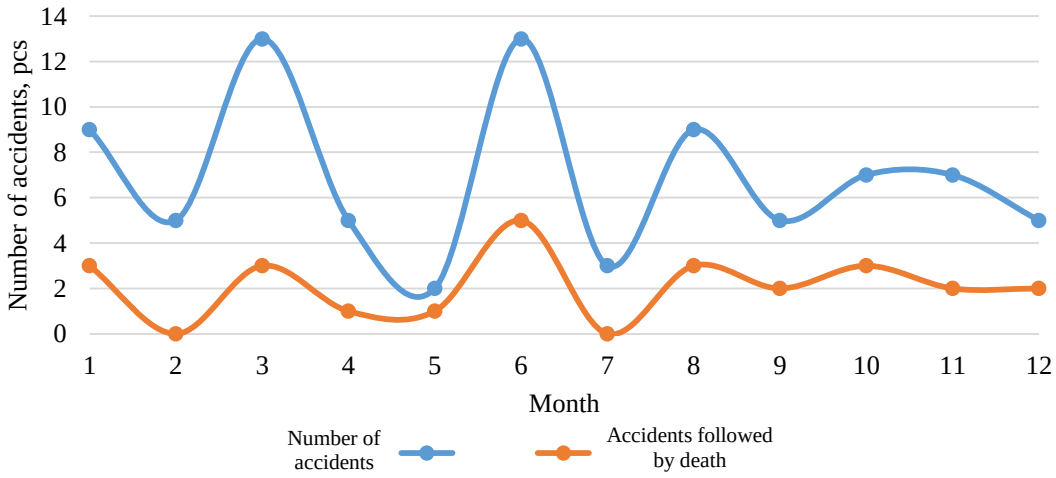


Fig. 4. Distribution of accidents at nuclear power plants for the period from 2013 to 2020 by months

The distribution of accidents by days of the week shows that the largest number of accidents at nuclear power plants occurs at the beginning of the week (Monday and Tuesday) and decreases by the end of the calendar week (Fig. 5).

At the same time, the greatest number of fatal injuries was noted on Thursdays and Fridays, which is probably due to a decrease in concentration due to fatigue accumulated by the end of the working week.

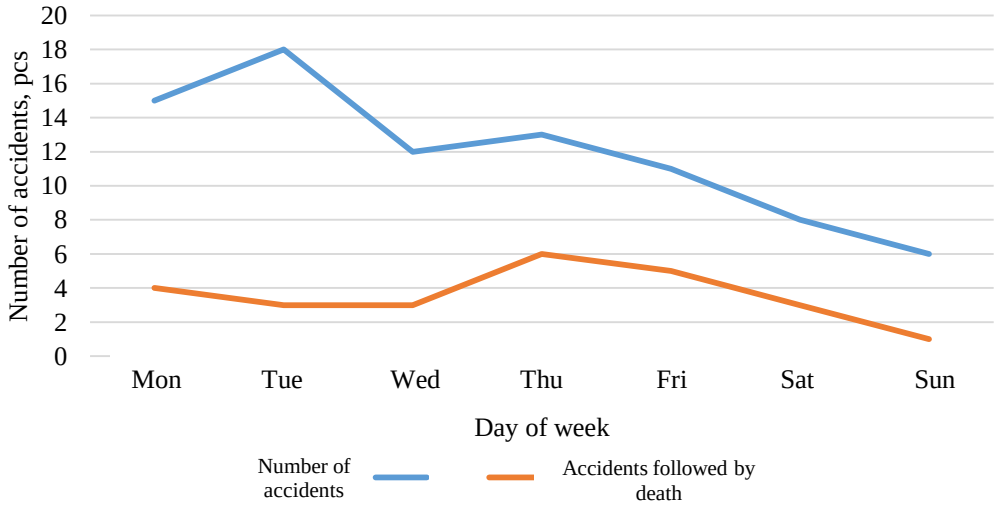


Fig. 5. Distribution of accidents at nuclear power plants for the period from 2013 to 2020 by days of the week

**Conclusions.** The article analyzes statistical data on cases of occupational injuries in the energy division of the Rosatom State Corporation for eight years, on the basis of which absolute and relative injury rates are calculated, the causes of accidents, the main traumatic factors, the most traumatic professions and periods of injury are determined.

In addition, it was revealed that injuries among employees of contracting organizations are significantly higher than among NPP personnel. This means that it is necessary to find out ways to reduce injuries at nuclear power plants by focusing on working with the employees of contracting organizations.

To do this, the authors have developed the following recommendations:

1. Preliminary qualification selection of contractor organizations with familiarization with the available statistics of occupational injuries cases, possibly with the compilation of a black list of contractors and individual specialists, determination of the rating of desirable contractors.

2. Interaction with contractors in digital format, creation of a "Contractor's Personal Account" to simplify work and reduce the time for processing information.

3. Consideration of the possibility of conducting unscheduled safety briefings with employees of contracting organizations in the most traumatic periods with the involvement of the employees of labor protection department [18].

4. Due to the increase in the level of injuries by the end of the working week, organization of a strict monitoring of compliance with the labor regime, without overwork and with mandatory regulated breaks.

5. For professions that are most susceptible to occupational injuries, apply special requirements to the quality of training of employees, knowledge checks, allow personnel of contractors who have passed a psychophysiological examination to work at nuclear power plants, introduce surprise inspections for drug and alcohol intoxication [19].

6. To develop schemes for motivating employees of third-party organizations to comply with the labor protection requirements, in particular, to introduce a system of incentives based on the results of work without injury for the year /half of the year [20].

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D. L. Ignatovskaya — calculations, text preparation, analysis of the research results, formulation of the conclusions; E. V. Shchekina — formulation of the main concept, goals and objectives of the study, finalization of the text, conclusions correction.