

Methods for Calculating the Socio-Economic Losses Caused by Industrial Accidents

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Abstract

This article presents and summarizes traditional methods used to calculate the socio-economic losses resulting from accidents that occur in technical or technological processes across various sectors of the economy. It describes how these approaches are applied to evaluate the consequences of industrial hazards for safety, injuries, emergencies, and the use of labor resources.

Keywords: Accident; Hazard; Safety; Analysis; Injury; Technological Processes; Industrial Safety; Emergencies; Labor Resources

Introduction

Since the emergence of humankind, people have been continuously developing and expanding the environment known as the *technosphere* in order to create favorable living conditions for themselves and their families within the biosphere. Consequently, every individual is considered the main driving force in shaping, developing, producing, and managing the society in which they live. Under the influence of these forces, countries develop, and the socio-economic living conditions of the population take shape.

At the same time, the frequency of hazardous and harmful factors in industrial enterprises — which are integral elements of the technosphere — continues to increase. From this point of view, in the *“Human–Machine–Environment”* system, both the number and types of accidents, disasters, occupational injuries, and occupational diseases are on the rise.

Research Relevance

As one of the founders of the theory of human life activity, the French philosopher F. Marshall, noted: “Every human activity is dangerous...” — a statement that has proven to be true in today’s world [4]. Indeed, in our pursuit of safety within the technospheric environment and to ensure comfortable living conditions for people in industrial and social settings, we have developed automated and mechanized systems, as well as various household electrical appliances and devices (such as electric and gas stoves, lighting systems, etc.). However, as a result, we have also created a complex of hazardous and harmful factors that affect both the human living environment and the surrounding ecosystem.

Therefore, ensuring occupational safety and protecting the health of workers in modern enterprises has become one of the key factors in the social development of society. From this perspective, research in this area will remain relevant throughout the evolution of human civilization.

Theoretical and Methodological Foundations of the Research:

Since the dawn of human civilization, the need to ensure occupational safety and study the hazardous factors that arise during labor activities has been a constant concern. Consequently, early studies addressing human safety in labor can be found even in the works of ancient scholars such as Aristotle (384–322 BC) and Hippocrates (460–377 BC).

The Great Scholar of the Renaissance Period — Paracelsus (1493–1541)

Paracelsus, one of the most prominent scholars of the Renaissance, studied the hazardous factors that arise in mining activities. In his works, he stated: “All substances are poisons, and all substances are medicines. It is only the dose that makes one a poison and another a remedy.”

The German scientist Agricola (1494–1555), in his famous work “On Mining,” as well as the Italian scholar Ramazzini (1633–1714) and the Russian scientist M. V. Lomonosov (1711–1765), paid great attention to issues of labor protection in their research and writings.

During the 19th century, as industrial development accelerated, a number of scientists emerged who conducted extensive research on occupational safety and protection. Among them were V. L. Kirpichev (1845–1913), A. A. Bess (1857–1930), D. R. Nikolskiy (1855–1918), V. A. Levitskiy (1867–1936), A. A. Skochinsky (1874–1960), and S. I. Kaplun (1897–1943) [5].

From our homeland, notable contributions to this field were made by O. Q. Qudratov in the light industry sector, T. I. Iskanderov in the field of occupational hygiene, O. R. Yo‘ldoshev and G‘. Yormatov in the industrial and construction sectors, and H. E. G‘oyipov in the agricultural sector. These scholars conducted profound theoretical research and developed practical, effective solutions to issues related to labor protection and industrial safety.

Research Objective

The main objective of this study is to improve traditional methods of calculating the socio-economic losses associated with injuries (or fatalities) of employees and other individuals resulting from accidents in technological processes, as well as to develop measures aimed at ensuring safe and healthy working conditions in industrial enterprises.

Based on this objective, the following tasks were addressed:

1. To analyze measures aimed at ensuring safe and healthy working conditions in industrial enterprises;
2. To calculate socio-economic losses associated with injuries (or fatalities) of employees and other individuals resulting from accidents in technological processes using traditional methods, and to develop improvements to these methods.

Research Methods

In the course of the research, methods such as analysis of scientific and educational literature, comparative analysis, generalization, as well as programming and digital modeling techniques were applied.

Results and Discussion

The methodology for calculating socio-economic losses related to injuries (or fatalities) of employees and other individuals resulting from accidents in technological processes, and for implementing measures to ensure safe and healthy working conditions in industrial enterprises, has been improved based on traditional calculation methods.

Main Part: Socio-Economic Losses, Socio-economic losses in production activities include compensation and operational costs resulting from the death of employees ($P_{g,p}$), death of third parties ($P_{g,t,l}$), and/or injuries to employees ($P_{t,p}$) and third parties ($P_{t,t,l}$) [6]:

$$P_{se} = P_{g,p} + P_{g,t,l} + P_{t,p} + P_{t,t,l} \quad (1)$$

In this case, the costs associated with the death of employees are determined as follows [2,3]:

$$P_{g,p} = S_{pog} + S_{p,k} \quad (2)$$

where: S_{og} – the cost of funeral benefits paid to the deceased, in soums; S_k – the expenses for paying benefits to dependents in the event of the breadwinner's death, in soums.

The costs associated with injured employees can be calculated using the following formula [2,3]:

$$P_{t,p} = S_v + S_{i,p} + S_m \quad (3)$$

where: S_v – expenses for payment of temporary disability benefits, in soums; $S_{i,p}$ – expenses for paying pensions to persons who have become disabled, in soums; S_m – expenses for medical, social, and professional rehabilitation of victims, including compensation for damage to their health, in soums.

In addition, when determining the total socio-economic losses (PSE), compensation for moral damages to both the victims themselves and their relatives may also be considered.

Losses Caused by Fatalities as a Result of Accidents at Hazardous Industrial Facilities. Losses resulting from fatalities ($P_{g.t.l}$) and injuries ($P_{t.t.l}$) to third parties due to accidents at hazardous industrial sites are determined in a similar manner.

Expenses for funeral benefits paid in the event of death are determined based on the average cost of funeral services available in the given region on the date of the incident.

In the event of the death of the breadwinner, the following individuals are entitled to receive survivor benefits [2,3]:

- persons with disabilities who were dependent on the deceased or who had the right to receive alimony from the deceased on the day of death;
- a child born after the death of the deceased;
- the children, grandchildren, brothers, and sisters of the deceased who are under 14 years of age;
- regardless of age or work ability, one of the parents, the spouse, or another family member who does not work because they are caring for the deceased's dependent children, grandchildren, brothers, or sisters under 14 years old;
- family members who have reached the established retirement age but, according to the conclusion of the state medical-social examination service or state healthcare institutions, are deemed to require outside assistance due to their health condition.

Thus, the total socio-economic losses resulting from fatalities and injuries to third parties are calculated by considering both direct and indirect costs associated with compensation, medical and social support, and funeral expenses.

Persons Entitled to Survivor Benefits and Calculation of Compensation

Individuals who were dependents of the deceased and became disabled within five years from the date of death are also entitled to survivor benefits.

Monthly compensation payments in the event of the loss of a breadwinner are made as follows:

- For minors – until they reach the age of 18;
- For full-time students over the age of 18 – until they complete their education, but not beyond the age of 23;
- For women aged 55 and above, and men aged 60 and above – for life;

- For persons with disabilities – for the entire period of disability;
- For one of the parents, a spouse, or another family member who is caring for the deceased's dependent children, grandchildren, brothers, or sisters – until those dependents reach the age of 14, or for the duration of the caregiver's disability, if applicable.

The amount of monthly payments in the event of the loss of a breadwinner is recommended to be calculated based on the deceased's average monthly wage, excluding the portion attributable to the deceased themselves and other able-bodied individuals. This calculation also deducts any pensions, lifetime annuities, and similar payments.

Compensation for Damage to the Victim's Health (Sm).

Expenses related to compensation for harm to the victim's health, including medical, social, and professional rehabilitation, consist of the following costs:

- additional medical assistance (beyond that provided under compulsory health insurance), including the purchase of additional food and medicines;
- provision of assistance (special medical and household care) to the victim, beyond what is provided by the victim's family members;
- treatment at a sanatorium or health resort, including payment for leave (in addition to the annual paid leave established by the legislation of the republic) for the entire treatment period, as well as the victim's travel expenses to and from the treatment location;
- if necessary, payment of travel expenses to and from the treatment location for the accompanying person, as well as their accommodation and meal costs;
- prosthetics, as well as providing the victim with tools and devices necessary for work and household needs;
- provision of special motor vehicles, payment for their current and major repairs, and for fuel and lubricants;
- vocational training (retraining).

Temporary disability benefits are paid at 100% of the average salary for the entire period during which the victim is unable to work, either until full recovery or until permanent loss of professional working capacity occurs, in accordance with legal regulations [2,3].

Permanent disability compensation is calculated based on the degree of loss of professional working capacity. The amount is determined as a proportion of the victim's

average monthly wage prior to the accident, reflecting the extent to which their ability to work has been reduced[2,3].

These measures ensure that victims of industrial accidents are provided with full socio-economic support, including medical, social, and occupational rehabilitation, thereby minimizing long-term economic and social losses.

The degree of loss of professional capacity of the victim is determined by the medical-social examination institution.

In regions where regional coefficients and percentage allowances are established, the amount of payment is determined taking these coefficients and bonuses into account.

If it is not possible to obtain a document regarding the victim's salary, the monthly insurance payment is calculated based on the tariff rate (official salary) established for this occupation in the industry (or sub-sector) and similar indicators.

Damage to the life and health of third parties can be determined either based on the amount of claims made or according to the same principles used to assess damage caused to employees as a result of an accident at a hazardous production facility.

To determine the total socio-economic losses from an accident, sources of information may include materials from the technical investigation of the accident, temporary disability certificates, statements from the victims or the family members of the deceased (victims), conclusions of the medical-technical expert commission, orders on compensation and benefit payments, decisions of trade unions, courts, and regional authorities, data from insurance companies, and other similar conclusions.

To calculate the projected amount of socio-economic damage, the following indicators can be used: the number of people within the affected zone of hazardous factors, the average age of employees at the enterprise, the average salary of employees, the proportion of men and women in the enterprise, the average number of dependents per employee, as well as the average cost of medical and burial services for a specific region.

When assessing the projected socio-economic damage to third parties, similar indicators can be used either for enterprises (legal entities) in the affected area or for a specific region (individuals).

For example, the damage caused to company employees as a result of accidents related to production technological processes is calculated as follows:

1. Funeral expenses ($S_{p.k}$): The average cost of funeral services, $S_{pog} = 6$ million UZS. The deceased had two children aged 9 and 13 under their care. The duration for paying pensions for the loss of the breadwinner:

$$(18 - 9) \cdot 12 = 108$$

$$(18 - 13) \cdot 12 = 60$$

$$\text{total duration: } 108 + 60 = 168 \text{ months}$$

The deceased's average monthly income = 6 million UZS. The deceased's spouse is employed. Thus, the monthly payment for each child:

$6 \cdot (1 - 2/4) / 2 = 1,5$ million UZS Thus, the total compensation for losing a breadwinner is:

$$S_{p.k} = 1.5 \cdot 168 = 252 \text{ million UZS}$$

2. Medical, social, and occupational rehabilitation expenses for the injured employee (S_m):
2.4 million UZS – cost for one injured person to stay in the hospital for six days

1.7 million UZS – cost of purchasing necessary medicines 10.0 million UZS – cost of treatment at a sanatorium 6.0 million UZS – cost of professional retraining $S_m = 2,4 + 1,7 + 10,0 + 6,0 = 20, \text{ million UZS}$

3. Compensation for a permanently disabled employee (S_{pp}): Age of the injured person = 42 years

Duration of monthly compensation = $(60 - 42) \times 12 = 216$ months Monthly income loss = $6,0 - 3,0 = 3.0$ million UZS $S_{str} = 21,6 \cdot 3,0 = 648$ million UZS = 64,8 million UZS

4. Temporary disability allowance (S_B): Average monthly salary = 6 million UZS Number of working days in the month when the accident occurred = 21 days For the period from the day of the accident until permanent disability is established, calculated for 10 working days: $S_B = 6.0/21 \cdot 10 = 28,6$ million UZS

Thus, by summing all the expenses, the total socio-economic loss caused to the victim can be determined.

Here's the English translation of your text:

There were no claims from the victims or their relatives for moral damages.

As a result, the socio-economic losses caused by the death and injuries of company employees amounted to: $6,0 + 25,2 + 20,1 + 64,8 + 28,6 = 371,7$ million UZS

Additionally, a third party suffered a minor injury and filed a claim amounting to 1.0 mln rubles (including medical expenses and moral damages).

Thus, the total socio-economic damage amounted to approximately 371.9 mln UZS.

conclusion

Accidents in production-related technological equipment not only destroy key elements of economic sectors, buildings, and facilities but also cause employees and surrounding citizens to suffer various injuries or even death. Consequently, the company and social security (insurance) companies incur significant economic losses through compensation payments.

Therefore, continuous improvement of occupational safety and technical security systems in enterprises, funded for this purpose, as well as management and optimization of technological processes, can reduce the number of accidents and minimize their consequences. The funds allocated for these preventive measures are much smaller compared to the compensation payments for accident consequences and injured or deceased personnel, as evidenced by experience.

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