Possibility of reducing costs of mining operations – economic aspects of workplace accidents

Adam Duda
Faculty of Mining and Geology, Silesian University of Technology, Akademicka 2, 44-100 Gliwice, Poland.
adam.duda@polsl.pl

Abstract. The article presents methods of calculating costs of workplace accidents incurred by an employer, and the influence of the number and severity of accidents on changes in the amount of accident insurance contribution paid by an employer within the framework of the social security system.

1. Introduction
Work accidents are still a significant problem for employers, and, first of all, for the society. In 2016, in Poland, 87,183 people were injured in accidents, including 464 severe injuries and 239 fatalities. The factors which determine solutions chosen by employers, also in work-related safety, are usually economic ones. That is why it is so important to know how accidents impact the economic performance of an enterprise.

The issue of analysing costs of work accidents is nothing new, and the United States of America is the country which has paid a lot of attention to the problem. The reason may be the fact that the issue of accident costs is particularly important for employers in the countries where the burden of possible consequences of an accident, to a large extent, falls on an employer, rather than the society. The first ones to research the issue were H.W Heinrich [1], R.M. Simonds, and J.V. Grimaldi [2]. In Poland, in the interwar years, research on the costs of accidents was conducted by W. Adamiecki, A. Anasiewicz and E. Modliński. Even after the years, the main assumptions in calculating the costs have not changed. Works by H.W. Heinrich, R.M. Simonds, P. Compes and A. Soderqvist remain the foundation of the methods currently in use [3]. The methods are modified in the area of identifying direct and indirect costs and linking them with the benefits an enterprise draws from the high level of work related safety [4]. Nowadays, methods of calculating accidents costs are developed by e.g. M. Oxenburgh, P. Marlow, C. Zangemeister, U. Johanson and Marc de Greef. In Poland works by J. Rzepecki and Z. Pawłowska have a big influence on the research on accident costs and methods of calculating them.

2. Methods of calculating costs of work accidents in Poland
Nowadays in Poland the most common is calculating costs of accidents following J. Rzepecki’s proposal applied by the Central Institute for Labour Protection. According to its guidelines cost of accident is [5, 6]:

\[ K_{SO} = K_{ZO} + K_{PO} + K_{PSO} \]
where:

\( K_{SO} \) – total social cost of a work accident,
\( K_{ZO} \) – total cost incurred by the enterprise,
\( K_{PO} \) – total cost incurred by the victim and their family,
\( K_{PSO} \) – total cost incurred by the society.

Costs incurred by the society \((K_{PSO})\) are costs covered by the Social Insurance Institution (ZUS) or costs of treatment covered by the National Health Fund. They are e.g.:

- sickness benefit,
- rehabilitation benefit,
- complementary benefit,
- single indemnity,
- incapacity benefit, including training benefit,
- family allowance pension, additional payment to family allowance pension,
- nursing supplement,
- additional payment to family allowance pension for a double orphan,
- covering costs of dental treatment and vaccinations and providing orthopaedic items and aids specified by the Act.

The costs incurred by an enterprise include basic cost components which can be calculated with the following equation [6]:

\[
K_{ZO} = (K_{CS} + K_{PMIT} + K_{N} + K_{Z} + K_{ZP} + K_{SM} + K_{NP} + K_{OW} + K_{I}) - O
\]  

(2)

where:

\( K_{O} \) – total cost,
\( K_{CS} \) – cost of lost time,
\( K_{PMIT} \) – cost of first aid and transport,
\( K_{N} \) – cost of overtime,
\( K_{Z} \) – cost of replacement personnel,
\( K_{ZP} \) – costs of interruptions in production,
\( K_{SM} \) – cost of material losses,
\( K_{NP} \) – cost of repairs,
\( K_{OW} \) – cost of financial compesation
\( O \) – compensation received from insurance institutions.

As the above equation shows, calculating costs of accidents which are incurred by an employer is not difficult. The problem is availability of data. The accounting system used by employers makes it hard to obtain data on to what extent the costs associated with accidents can be directly extracted basing on analytical accounts. Lack of easy identification of accident costs in the accounting system makes it hard, yet not impossible, to analyse costs of accidents. It is possible to perform such an analysis when data, even raw ones, are available for an analyst. Such analyses are conducted in many enterprises, particularly in the ones which, due to an accident, receive compensations from insuring companies. However, the data are rarely shared with third parties, which is fully understandable, but results in lack of such data for research.

Data concerning costs of accidents incurred in one of coal mines in 2006-2008 showed that the average cost of an accident incurred by the employer was then approximately 8 000.00 PLN. What is important, the analysed accidents did not stop the production. They were work accidents where there was no material damage and the employer did not incur any costs of interrupted production process. The accidents which interrupt (lower) production, also cause huge losses – most often they are catastrophes or incidents caused by forces of nature of great potential, in which employees are victims.
In the literature, it is assumed that the cost of an accident incurred by an employer is 25% of the total cost of an accident i.e. approximately 75% of the costs is incurred by ‘the society’ namely the state budget (ZUS, NFZ)[3]. Such a large share of the costs of accidents incurred by the society means that the State tries, through various mechanisms, 11.00 promote safety at work and ‘reward’ the employers with the fewer and less severe accidents than other employers within the same business activity (PKD).

3. Differentiating accident insurance contribution depending on the risk category

By implementing motivational social security systems, it is possible to make employers perceive work related safety as an economic benefit. In Poland, regulations which enable differentiating the amount of accident insurance contribution were introduced by the regulation of the Minister of Labour and Social Policy of 29 November 2002 on differentiating social insurance contribution in respect of accidents at work and occupational diseases in relation to occupational hazards and their effects (Journal of Laws of 2002, No. 200, item 1692 as amended). According to the regulation, the amount of accident insurance contribution for a business activity is calculated on the basis of the risk category for a business activity determined basing on partial risk categories $K_1$, $K_2$, $K_3$, $K_4$ following the equation below [7]:

$$K_{DX} = \frac{K_1 + K_2 + K_3 + K_4}{4}$$  \hspace{1cm} (3)

where:

- $K_{DX}$ – risk category for given business activity,
- $K_1$ – risk category corresponding the rate of injuries in work accidents, total,
- $K_2$ – risk category corresponding the rate of fatalities and severe injuries in work accidents,
- $K_3$ – risk category corresponding the rate of personnel working in hazardous conditions, occurring when the highest admissible concentrations and intensity of factors detrimental to health in the work environment are exceeded,
- $K_4$ – risk category corresponding the rate of occupational diseases.

To determine given risk categories, it is necessary to start with calculating the rate of:

- total injuries in work accidents,
- fatalities and severe injuries in work accidents,
- personnel working in hazardous conditions, occurring when the highest admissible concentrations and intensity of factors detrimental to health in the work environment are exceeded,
- recorded occupational diseases.

Given indices are calculated per 1 000 employees and determined separately for a full calendar year for business activities. Basing on the dependences, risk category for a business activity is calculated and together with accident insurance contribution they are attached to the aforementioned regulation.

Another element which, together with risk categories, influences the interest rate of an accident insurance contribution determined for given contribution payers within their business activities, i.e. its increase or decrease, is so-called adjustment factor. The adjustment factor is determined individually for each contribution payer i.e. basing on the difference between risk category specified in the regulation for a business activity, which given contribution payer belong to, and given contribution payer’s risk category determined with the dependence [7]:

$$K_{ZX} = \frac{K_1 + K_2 + 2K_3}{4}$$  \hspace{1cm} (4)

where:

- $K_{ZX}$ – risk category for each given contribution payer.

The basis to determine partial risk categories are arithmetic means of the rates of [7]:

\[
\text{average} = \frac{\text{sum of all rates}}{\text{number of rates}}
\]
• total injuries in work accidents \(W_1\),
• fatalities and severe injuries in work accidents \(W_2\),
• personnel working in hazardous conditions, occurring when the highest admissible concentrations and intensity of factors detrimental to health in the work environment are exceeded \(W_3\).

The rates are calculated per 1 000 insured persons and determined for contribution payers separately for a full calendar year following the equations [7]:

\[
W_1 = \frac{P_1}{U} \times 1000
\]
\[
W_2 = \frac{P_2}{U} \times 1000
\]
\[
W_3 = \frac{P_3}{U} \times 1000
\]

where:
\(P_1\) – total number of victims injured in work accidents;
\(P_2\) – number of victims injured in fatal and severe work accidents;
\(P_3\) – number of personnel working in hazardous conditions, occurring when the highest admissible concentrations and intensity of factors detrimental to health in the work environment are exceeded;
\(U\) – number of insured persons,

Arithmetic means of rates \(W_1, W_2, W_3\) are the basis to determine partial risk categories \(K_1, K_2, K_3\). Arithmetic means of the rates are calculated basing on the last three consecutive calendar years.

As the above dependences show, the number of victims injured in work accidents and their severity determine which risk category a contribution payer i.e. employer will fall into.

After calculating risk category for an employer it has to be compared with risk category for a business activity (PKD) and apply adjustment factor of [7]:

- 0.5 - if the risk category determined for contribution payer is by at least 6 categories lower than the risk category determined for a business activity;
- 0.6 - if the risk category determined for contribution payer is by 5 categories lower than the risk category determined for a business activity;
- 0.7 - if the risk category determined for contribution payer is by 4 categories lower than the risk category determined for a business activity;
- 0.8 - if the risk category determined for contribution payer is by 3 categories lower than the risk category determined for a business activity;
- 0.9 - if the risk category determined for contribution payer is by 2 categories lower than the risk category determined for a business activity;
- 1.1 - if the risk category determined for contribution payer is by 2 categories higher than the risk category determined for a business activity;
- 1.2 - if the risk category determined for contribution payer is by 3 categories higher than the risk category determined for a business activity;
- 1.3 - if the risk category determined for contribution payer is by 4 categories higher than the risk category determined for a business activity;
- 1.4 - if the risk category determined for contribution payer is by 5 categories higher than the risk category determined for a business activity;
- 1.5 - if the risk category determined for contribution payer is by at least 6 categories higher than the risk category determined for a business activity;
- 1.0 – in other cases.
According to current legal regulations, in extreme cases, an employer will pay either 50% more or 50% less for accident insurance. Business activity: ‘Mining of hard coal and lignite’ falls into risk category 12 and the interest rate of the contribution is 3.33% [7]. The number may not reflect the financial scale obtained due to differentiating accident insurance contribution hence it is worth to simulate it. Assumptions and results of such a simulation are presented in Table 1.

**Table 1.** Simulated changes in accident insurance contribution.

| Year | Data                              | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|------|-----------------------------------|------|------|------|------|------|------|------|------|
|      | Number of people injured          | 3382 | 3370 | 3310 | 3254 | 3198 | 3121 | 3100 | 3091 |
|      | Number of people injured in accidents | 47   | 38   | 50   | 41   | 21   | 18   | 23   |      |
|      | Number of fatalities and persons severely injured in accidents | 1    | 0    | 0    | 0    | 0    | 0    | 0    |      |
|      | Number of personnel working in dangerous conditions | 983  | 971  | 951  | 942  | 921  | 901  | 894  |      |
|      | Rate of total injuries (W₁)       | 13.897 | 11.276 | 15.106 | 12.600 | 6.567 | 5.767 | 7.419 |      |
|      | Rate of fatalities and severe injuries (W₂) | 0.296 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |      |
|      | Rate of personnel working in dangerous conditions (W₃) | 290.66 | 288.13 | 287.31 | 289.49 | 287.99 | 288.69 | 288.39 |      |
|      | Rate calculated on the basis of the last three calendar years to determine partial categories (W₁, W₂, W₃) |      |      |      |      |      |      |      |      |
|      | Rate of total injuries (W₁)       | 13.4 | 13.0 | 11.4 | 8.3  | 6.6  |      |      |      |
|      | Rate of fatalities and severe injuries (W₂) | 0.099 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |      |
|      | Rate of personnel working in dangerous conditions (W₃) | 289  | 288  | 288  | 289  | 288  |      |      |      |
|      | Risk category K₁                  | 10   | 10   | 9    | 7    | 6    |      |      |      |
|      | Risk category K₂                  | 5    | 1    | 1    | 1    | 1    |      |      |      |
|      | Risk category K₃                  | 9    | 9    | 9    | 9    | 9    |      |      |      |
|      | Risk category for given business activity (K_DX) | 12   | 12   | 12   | 12   | 12   |      |      |      |
|      | Contribution for given business activity | 3.33% | 3.33% | 3.33% | 3.33% | 3.33% |      |      |      |
|      | Risk category for given employer (K_ZX) | 8    | 7    | 7    | 7    | 6    |      |      |      |
|      | Difference between categories     | 4    | 5    | 5    | 6    | 6    |      |      |      |
|      | Adjustment factor                 | 0.7  | 0.6  | 0.6  | 0.5  | 0.5  |      |      |      |
The Role of Polish Coal in the National and European Energy Sector

IOP Conf. Series: Materials Science and Engineering 268 (2017) 012009 doi:10.1088/1757-899X/268/1/012009

Contribution calculated for given employer

| Average monthly remuneration for calculating accident insurance contribution (PLN) | 2.33% | 2.00% | 2.00% | 1.67% | 1.67% |
| Total contributions paid by employer in one year (PLN) | 6000 | 6000 | 6000 | 6000 | 6000 |

For the presented calculations it was assumed that:

- in consecutive years number of accidents will halve,
- value of a risk category and contribution for a business activity is constant,
- number of employees working in conditions of exposure in relation to the number of insured persons will not change significantly (with such an assumption it is possible to presents benefits of decreasing the number of accidents)
- remuneration, which the contribution is calculated upon, is constant

The changes in the amount of accident insurance contribution, which an employer will have to pay in consecutive years are presented in figure 1.

![Figure 1.](image)

**Figure 1.** Accident insurance contributions which an employer will have to pay in consecutive years.

As the above graph shows, an employer, in relation to 2017, will pay a contribution lower: in 2018 by 860 738.40 PLN; in 2019 by 971 507.52 PLN; in 2020 by 1 744 973.28 PLN; in 2010 by 1 755 762.48 PLN. It has to be emphasised that the contribution was lowered from the value of accident insurance contribution already decreased by adjustment factor of 0.7.

4. Conclusions

It is an employer who has the greatest influence on creating safe working conditions. Costs of accidents incurred by an employer are not high enough to motivate them to take actions aimed at improving work-related safety – especially in case of the accidents which do not interrupt production or cause material damage, i.e. personnel’s most common accidents.

Nearly 75% of costs of accidents is incurred by the society and the victims themselves. Costs incurred by the society are paid with money collected by the Social Insurance Institution which come from accident insurance contributions and the financial means of the National Health Fund.

One of the methods to motivate employers to improve work-related safety in an enterprise is differentiating accident insurance contributions.
Results of the simulated change in the amount of accident insurance contribution paid by an employer depending on the number of accidents show that reducing the number by approximately 50% an employer may lower, within 4 years, accident insurance contribution by 5,332,981.68 PLN.

The mechanism of differentiating accident insurance contribution must not be ‘skewed’ by employers’ actions aimed at ‘moving’ accidents outside the workplace (accidents on the way to and from work), or creating systems of bonuses ‘motivating’ employees not to report accidents.

References
[1] Heinrich H W 1941 Industrial Accident Prevention (New York: A Scientific Approach McGraw-Hill)
[2] Simonds R M and Grimaldi J V 1956 Safety management: Accident cost and control (Illinois: Homewood Richard D. Irvin)
[3] Duda A 2010 Koszty wypadków przy pracy ponoszenie przez pracodawcę na przykładzie analizy kosztów w latach 2006-2008 w KWK "X" (Gliwice: Górnictwo zrównoważonego rozwoju Wydział Górnictwa i Geologii Politechniki Śląskiej CD-ROM) pp 1-6
[4] Szlązak J and Grodzicka A 2016 Ocena kosztów wypadków przy pracy i chorób zawodowych z punktu widzenia państw Unii Europejskiej Wiadomości Górnicze 4 pp 262–70.
[5] Rzepecki J 2005 Społeczne koszty wypadków przy pracy w Polsce. Bezpieczeństwo Pracy: Nauka i Praktyka, 7-8 pp 34-7.
[6] Rzepecki J 2015 Społeczne koszty wypadków przy pracy. Bezpieczeństwo Pracy: Nauka i Praktyka 5 pp 20-3.
[7] Rozporządzenie Ministra Pracy i Polityki Społecznej z dnia 29 listopada 2002 r. w sprawie różnicowania stopy procentowej składki na ubezpieczenie społeczne z tytułu wypadków przy pracy i chorób zawodowych w zależności od zagrożeń zawodowych i ich skutków (Dz. U. 2002, Nr 200, poz. 1692 ze zm.)