ANALYSIS AND ASSESSMENT OF WORK SAFETY IN A POLISH MINING COMPANY – EMPIRICAL STUDY

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Abstract. An accident is caused by hazardous human behaviour, the operation of mechanical equipment or conditions of the work environment. This article presents an analysis of work safety in a selected mining company which takes in to account the following criteria: position, work experience in the mining industry, work experience in the company analysed, causes of the accident, nature of work, duties performed at the worksite, injury sustained in the accident and the employee's age.

Keywords: security; mining; accident; management.

1. Introduction

The outlook on work health and safety in the company changed along with the management conditions and the advancements of science and technology. Originally it was believed that the only negative consequence of work-related hazards are accidents caused by bad working conditions. Therefore, improvements to the material working conditions were strived for. Slightly later it was noticed that even in conditions that facilitate safety accidents can occur caused by human errors (Gieryń, 2006). Currently it is widely believed that proper management of work health and safety is the most effective way of ensuring them and should be an integral part of company management (Gembalska-Kwiecień, 2014; 2017). This is confirmed by studies and observations conducted in many countries. The basic principles of employee safety and health protection stem from the legislation of the particular country. In EU directives, which are implemented into all the member states' legislation, the requirements pertaining to work health and safety are described very broadly and encompass "traditional" issues (e.g. protection from the influence of hazardous and harmful agents, workplace design, work organisation, the obligation to consult with and inform the employees, trainings, etc.) (Hassa, 2007; Juras, and Krause, 2005). The primary objective of work safety in company management is the introduction of procedures at each of the management levels and making decisions that prevent the occurrence of hazardous events and accidents in the future. This requires the involvement

of the entire staff in the safety improvement programme and the acceptance of responsibility according to the decision-making powers (Parchański, 2004). Work safety management must encompass documented modules of the management system in form of operational procedures at all levels of management and decision-making. In every area of the company's activity all the technical and natural threats associated as well as coordinated preventive measures will be decisive in making the right decisions (Skotnicka-Zasadzień, 2010; Rozporządzenie Ministra Gospodarki i Pracy w sprawie statystycznej karty wypadku przy pracy, 2004).

This article presents an analysis of work safety in an exemplary mining company in the years 2011-2016.

2. Assessment of safety in the mining company

The company discussed in the present article provides the following mining services: drilling underground excavations, reconstruction of underground excavations, underground drilling works, creating stand-alone rockbolt supports and roof injections, furnishing excavations with technical equipment as well as disassembly of such equipment (especially removals and reinforcement of mechanised longwall systems).

The following criteria were taken into account in the assessment of safety in the mining company:

- position,
- work experience in the company analysed,
- causes of the accident,
- nature of work,
- task performed at the workplace,
- injury sustained in the accident,
- employee's age.

2.1. Analysis of accident rates in the mining company according to position

The analysis conducted (Table 1) suggests that miners who work directly at the face are involved in accidents the most often. The most accidents took place in the years 2014 and 2016. Not far behind in the statistics are accidents caused by employees involved with transport. These results confirm that miners extracting materials directly at the face and those who transport them are the most likely to sustain accidents.

Table 1.
Accidents in the mining company analysed in the years 2011 - 2016 – division according to employee position

Position	2011	2012	2013	2014	2015	2016
Supervisor	1	1	0	4	0	3
Miner	9	12	9	15	14	15
Junior miner	0	1	2	4	4	7
Carpenter	0	1	3	4	2	1
Locksmith	2	1	2	4	2	1
Electrician	2	1	0	1	0	2
Transport worker	4	5	13	7	11	14
Washer operator	0	0	2	1	1	1

2.2. Analysis of accident rates in the mining company according to work experience

Analysis of accident rates according to work experience in the mining company (Table 2) overlaps with the analysis according to work experience in the mining industry. The largest number of accidents is caused by employees with little professional experience in the company, i.e. under 2 years of experience. Based on the analysis it can be concluded that lack of experience and practice is the cause of numerous accidents. Only slightly fewer accidents are caused by employees with over 5 years of work experience, which, in turn, can serve as proof that routine and overconfidence cause a lack of sufficient diligence with regards to safety.

Table 2.
Accidents in the mining company analysed in the years 2011 - 2016 – division according to work experience in the company

Work experience in the mining company	2011	2012	2013	2014	2015	2016
over 5 years	8	4	10	9	1	8
4-5 years	3	1	3	0	4	3
3-4 years	0	2	2	4	1	2
2-3 years	0	3	5	7	2	3
1-2 years	1	4	8	11	1	4
under 1 year	7	8	16	18	4	6

2.3. Analysis of accident rates in the mining company according to the cause of accident

The most accidents in the company are caused by a hit with a stone block as well as loss of balance – slipping. The remaining causes constitute only a small number of accidents (Table 3).

Table 3.
Division of accidents according to cause in the years 2011-2016

Cause	2011	2012	2013	2014	2015	2016
Hit with a stone block	1	4	12	10	13	15
Hit with part of the support	7	4	7	8	6	5
Hit with a device (machine)	2	4	3	2	3	2
Hit with a simple tool	1	2	1	3	1	4
Hit with a chip	1	3	1	4	2	2
Hitting a stationary item	1	2	1	2	1	3
Stab with a sharp element	1	1		2	1	1
Loss of balance (slipping)	6	5	9	13	9	11

cont.table 3

Abrasion	1	1	2	3	1	1
Strain on the muscular system	1	1	2	1	2	1
Fall from a height	1	2	2	1	1	1
Lye burn	1	1	3	1	1	1
Stroke	1	2	1	1	1	2
Derailment of a passenger train	0	0	0	0	0	0

2.4. Analysis of accident rates in the mining company according to the type of mining works conducted

The largest number of accidents was noted during the drilling of faces, as it is the main and most complicated operation performed by the employees of the company. Slightly fewer accidents occurred during the removal and reinforcement of walls – these tasks are especially dangerous and complicated. As much as 12% of the accidents occurred while the employees were traveling to their workplace. It can be concluded that this was caused by lack of attention and focus on the employees' part (Table 4).

Table 4.
A juxtaposition of accidents in the mining company in the years 2011 - 2016 according to the type of mining works conducted

Type of task	2011	2012	2013	2014	2015	2016
Drilling of excavations	5	9	19	20	17	16
Removal (reinforcement) of walls	7	6	6	0	4	4
Reinforcement (removal) of a face	0	1	1	0	1	1
Excavation reconstruction	3	4	0	2	1	4
Strengthening of the support	0	1	0	0	0	0
Bottom taking	0	0	0	0	0	0
Coal processing	0	0	1	2	0	1
Trackway reconstruction	1	0	0	0	0	0
Travel to the worksite	2	2	4	1	1	3
Storing tools	1	0	0	0	0	0
Work supervision	0	0	0	3	0	2
Showering in the baths after work	0	0	2	0	0	2

2.5. Analysis of accident rates in the mining company according to the activities performed by the employees

Analysis according to the type of activity performed has shown that the most accidents occurred during transport of the output and support construction. Such a juxtaposition of accidents according to the activity performed overlaps with the previous criterion, i.e. type of works conducted by the employees at the time of the accident (Table 5).

Table 5.
Juxtaposition of accidents in the mining company according to the activity performed in the years 2011-2016

Activity	2011	2012	2013	2014	2015	2016
Drilling of blast holes	1	0	0	0	0	1
Working with a shearer	0	0	0	1	1	1
Extracting output	0	2	0	2	0	1

cont. table 5

Support construction	3	3	10	8	1	7
Barring-down	0	1	0	0	0	0
Support reinforcement	2	0	0	4	1	0
Construction of air duct	0	0	1	0	0	0
Taking (returning) a lamp	0	0	0	1	0	0
Conveyor maintenance (operation)	0	1	0	2	2	0
Machine repair (maintenance)	0	0	1	3	0	0
Using simple tools	1	1	1	5	0	0
Transport using small-gauge train	1	1	0	0	0	0
Manual transport	6	8	12	9	7	2
Moving around	3	2	8	9	5	2
Travelling by train	0	0	0	0	0	0
Storing tools	1	0	0	0	0	0

2.6. Analysis of accident rates in the mining company according to the type of injury sustained

The main injuries are concussions and fractures, superficial wounds and joint sprains. Over the course of the company's activity 10 different types of injuries had been observed. The most common injuries are caused by various types of hits sustained while conducting works, mostly due to the operating machinery or rocks falling from the rock mass (Table 6).

Table 6.
Accidents in the mining company in the years 2011-2016 – division according to the type of injury sustained

Injury	2011	2012	2013	2014	2015	2016
Concussion	4	5	7	11	9	7
Superficial wound	1	4	7	6	3	4
Fracture	6	7	6	16	9	8
Joint sprain	3	2	6	6	4	5
Finger amputation	1	1	1	0	2	1
Tendon rupture	0	1	2	1	1	1
Burn	0	0	1	1	0	0
Meniscus	0	0	1	1	0	1
Stroke	1	0	0	0	0	0
Loss of sight	1	0	1	0	0	1

2.7. Analysis of accident rates in the mining company according to the type of injury sustained

The largest number of accidents have been observed for young employees under 30 years of age, which may be evident of a lack of experience and foolhardiness. It is surprising that the most accidents involved employees between 40 and 45 years of age, which would suggest too high routine and low focus during work (Table 7).

Table 7.
Division of accidents in the mining company according to the age of the employee for the years 2011-2016

Age	2011	2012	2013	2014	2015	2016
over 45 years	2	6	1	5	3	2
40-45 years	4	7	7	9	9	9
35-40 years	2	0	1	7	1	2
30-35 years	0	2	3	7	3	2
25-30 years	2	5	11	8	6	5
20-25 years	3	2	10	10	6	5

In the mining company discussed only light accidents and no fatal ones were observed in the years 2011-2016. In 2011 there were 15 of them, in 2012 – 17, 2013 – 30, 2014 – 4, 2015 – 39 and as many as 47 in 2016. This may be connected with the increase in the number of orders for mining works in the recent years as well as conducting works in different mines, where the mining and geological conditions vary greatly.

3. Accident rate indicators for the mining company in the years 2011-2016

According to article 236 of the Polish Labour Code, every employer is obliged to – under the pain of fine – systematically analyse the causes of workplace accidents and introduce appropriate preventive measures based on these analyses (Rozporządzenie Ministra Gospodarki i Pracy w sprawie statystycznej karty wypadku przy pracy, 2004; Ustawa o ubezpieczeniu społecznym z tytułu wypadków przy pracy i chorób zawodowych, 2002). Analysis of accident rates has that primary objective, i.e. prevention (Gembalska-Kwiecień, 2017). It should illustrate the current situation in terms of accident rates in the company, type of works, technologies and positions with especially high accident risk, as well as the scope of measures aimed at removing these hazards. The analysis is conducted statistically according to frequency, severity and loss indicators.

These indicators are calculated using the following formulas:

- accident severity indicator: $C = {}^{D_S}/_{W}$

  where:

  D_s – days lost due to accidents,

  W – number of accidents;

- accident frequency indicator: $W_c = {}^{W}/_{Z}$

  where:

  W – number of accidents in the report-making period,

  Z – average employment in that period;

- generalised loss indicator: $W_{US} = {W \times C}/{Z}$

  where:

  W – number of accidents,

  Z – number of employees,

  C – severity.

When assessing the recurrence of accidents using these indicators the following factors are taken into account: place of accident, type of accident, procedures, causes of accidents. Comparative analysis of accidents consists in juxtaposing accidents according to specific criteria, e.g.: type of injury, activities during which accidents occur, work processes during which injuries are sustained, causes of the accident, employee's age, work experience in the mining industry and in the company, professional qualifications of the victims.

3.1. Accident severity indicator

The year 2011 was the worst for the company in terms of accident severity, with the indicator reaching 55.1, i.e. every accident caused an almost two-month absence of the victim from work. As can be seen, this indicator varies greatly, which is connected with high employment dynamics and employee rotation in the recent years. The analysis conducted shows that it is not the number of accidents that is a detrimental factor to the company, but rather the type of injury which determines the lengths of rehabilitation and sick leave taken by the employee (Table 8).

Table 8.
Juxtaposition of accident severity indicators for the years 2011-2016

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Accident severity indicator	55.1	32.7	27.0	41.3	42.1	43.5

3.2. Accident severity indicator

The highest frequency indicator was observed in 2015 and 2016, which is connected with the systematic rise in employment in the mining company. The company currently employs about 600 people, while at the beginning of its operation, i.e. in the year 2000, that number was 150 (Table 9).

Table 9.
Juxtaposition of the accident frequency indicator per 1000 employees in the years 2011-2016

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Accident frequency indicator	47.7	40.3	46.3	47.5	50.9	52.1

3.3. Accident severity indicator

The loss indicator in the years analysed varies and fluctuates from 1.3 in 2012 and 2013 to 2.8 in the year 2016, which is connected with the increased number and rotation of employees in the recent years, which translates to insufficient experience in a given position (Table 10).

Table 10.
Juxtaposition of the generalised loss indicator in the years 2011-2016

	2011	2012	2013	2014	2015	2016
Loss indicator	2.7	1.3	1.3	2.0	2.6	2.8

4. Conclusions

Despite measures taken to improve work safety in the mining company, an increase in the accident rates has been observed in the recent years, especially among young employees (Hassa, 2007). It appears that little work experience and lack of qualifications are the cause of this situation. Another factor contributing to the rise in accident rates may be the high rotation of employees. Measures aimed at preventing increase in the number of accidents include: increasing the number of trainings, introducing professional risk assessment sheets at all positions, implementing a health and safety management system and creating procedures connected with monitoring safety in the mining company. A well-functioning health and safety department must play a central role in monitoring and controlling the safety of employees, whose tasks should include:

- conducting health and safety controls as well as controlling the observance of regulations and rules connected with health and safety in the facility and any other workplace (mines, mining facilities),
- proposing the removal of accident hazards and lapses detected connected with health and safety to the persons in charge of employees,
- approaching the employer with propositions to award employees who stand out in striving to improve the health and safety conditions,
- taking disciplinary action against employees who neglect their duties in terms of work health and safety,
- immediately stopping the operation of a machine or other piece of technical equipment upon detecting a threat to the life or health of an employee or other persons,
- retiring an employee who, through their behaviour or the way they perform their work, causes a direct threat to their own or other persons' life or health.

Bibliography

1. Gieryń, M. (2006). Analiza ryzyka jako narzędzie oceny działań związanych z doskonaleniem systemu zarządzania jakością. *Problemy Jakości, 10*, 17-21.
2. Gembalska-Kwiecień, A. (2014). Kultura bezpieczeństwa pracy w przedsiębiorstwie a wypadkowość. *Promotor BHP, 7/8*, 38-43.
3. Gembalska-Kwiecień, A. (2017). *Czynnik ludzki w zarządzaniu bezpieczeństwem pracy w przedsiębiorstwie. Wybrane zagadnienia*. Gliwice: Wydawnictwo Politechniki Śląskiej, 142.
4. Hassa, A. (2007). Mierniki stanu bezpieczeństwa i higieny pracy w Polsce, Europie i na świecie. Artykuł dyskusyjny. *Bezpieczeństwo Pracy i Ochrona Środowiska w Górnictwie, 10*, 29-34.
5. Juras, J., Krause, M. (2005). Ocena wpływu wdrażania systemów zarządzania na poprawę stanu bezpieczeństwa w górnictwie. *Bezpieczeństwo Pracy i Ochrona Środowiska w Górnictwie, 2*, 20-26.
6. Parchański, J. (2004). Struktura wiekowa pracowników kopalń węgla kamiennego i jej wypadkowość w okresie restrukturyzacji zatrudnienia. *Zeszyty Naukowe, s. Górnictwo, 261*, 509-520.
7. Skotnicka-Zasadzień, B. (2010). Analiza bezpieczeństwa pracy w wybranym przedsiębiorstwie górniczym. *Ekonomika i Organizacja Przedsiębiorstwa, 4*, 6860-6864.
8. Rozporządzenie Ministra Gospodarki i Pracy w sprawie statystycznej karty wypadku przy pracy, Dz.U. 2004, Nr 269, poz. 2672.
9. Ustawa z dnia 30 października 2002 r. o ubezpieczeniu społecznym z tytułu wypadków przy pracy i chorób zawodowych, Dz.U. 2002, Nr 199, poz. 1673).