

## USE OF ACCIDENT ANALYSIS METHODS AT WORK TO DETERMINE RESPONSIBILITY FOR THE EVENT

doi: 10.2478/czoto-2023-0013

Date of submission of the article to the Editor: 07/11/2023

Date of acceptance of the article by the Editor: 06/12/2023

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**Abstract:** Carrying out professional work is inextricably linked to the risk of accidents while performing tasks at the workplace. Accidents at work involve a number of obligations on the part of the employer. One of the legally prescribed actions taken by employers is the need to indicate the cause or causes that led to the accident at work. Due to the implementation of social benefits and possible issues of civil liability for the events that occurred, it is often necessary to indicate the liability of the employee or employer. For this purpose, among other things, methods of analyzing accidents at work are useful, as they allow us to determine at least the causes, and usually also the primary causes, of the event. The results of this type of analysis can be used to quantify the shared responsibility for the events on the part of the employee and the employer.

The aim of the work is to present the possibility of quantitatively determining co-responsibility for an accident at work using the barrier analysis and the in-depth TOL method.

**Keywords:** accidents at work, TOL analysis, work safety

### 1. INTRODUCTION

Occupational safety is the result of the cooperation of all process participants: the employer, middle management and employees. In order to achieve the intended level of safety in the work environment, they have at their disposal a range of organizational and technical actions: collective and individual.

Despite high safety standards, which should be the goal of all safety-related activities, every year in Poland, several dozen thousand employees suffer accidents, including several hundred fatal accidents. All accident events, in accordance with applicable legislation in this field, are subject to analyzes carried out by a post-accident team appointed in this respect. One of the main points of the analysis is to determine the causes of the event and the responsibility for it. In practice, the ultimate direct cause of an accident at work is accompanied by a number of indirect causes, which are usually the result of errors and negligence in the organization of the work environment. From a legal point of view, proper determination of the causes of an accident at work and liability for their occurrence is very important. It may decide about possible benefits related to the injured person's recovery and the payment of compensation in this respect.

In Polish law, the final version of the accident and its qualification are decided by the employer and the Social Insurance Institution. If the employee does not agree with the conclusions contained in the post-accident report, he or she has the right to submit a dissenting opinion in writing and then appeal to the labor court. During court proceedings, it is often necessary to determine the involvement of the employee and the employer in the incident. For this purpose, accident analysis methods at work may be useful, as they help identify the direct and indirect causes of the event. Popular methods of investigating accidents at work include barrier analysis and the TOL method, which allow for a detailed analysis of the event.

The aim of the article is to indicate a method for determining the shares of liability of the employee and the employer in an accident at work, using the TOL method and barrier analysis.

## 2. ACCIDENTS AT WORK

The employer's primary obligation is to provide employees with safe working conditions by preventing work-related threats, organizing it properly, applying preventive measures and training employees (Rozporządzenie, 2003). If properly implemented, the obligation should protect employees against accidents at work and occupational diseases. An accident at work, in accordance with applicable law, is a sudden event caused by an external cause, which resulted in injury or death of the injured party, and additionally the event was related to work (Ustawa, 1974). An accident may occur during or in connection with the performance of ordinary activities by an employee assigned to him by or on behalf of the employer. The definition also includes the time the employee remains at the employer's disposal between the employer's registered office and the place of performance of the obligation arising from the employment relationship. In the event of an accident at work, each employer is obliged to take action to eliminate or reduce the risk. In addition, the employer is responsible for providing first aid to the injured, determining the circumstances and causes of the accident and applying appropriate measures to prevent future accidents. The analysis of causes should be systematic (Ustawa, 2003). In Poland, several tens of thousands of employees suffer from accidents every year (GUS, 2013-2023). The number of accidents decreases every year, as shown in Figure 1.

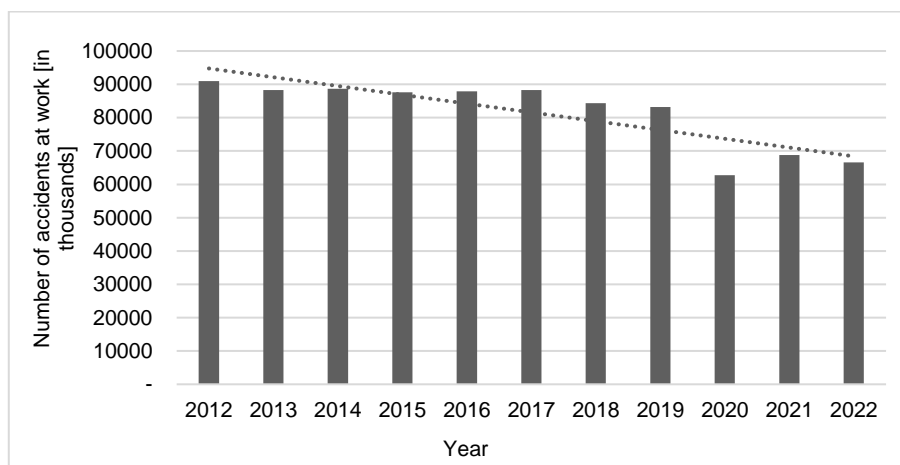


Fig.1. Number of accidents at work in Poland in 2012 – 2022

Source: Own work

In the years 2012 - 2019, the number of accidents remained at a similar level, approximately 87,000, and from 2020, approximately 66,000 people are injured in accidents at work annually. employees. One of the industries where the most accidents are recorded is industry, in particular mining and quarrying. Analyzing the number of injured miners per 1,000 workers, a tendency can be noticed that is inversely proportional to the total number of accidents in Poland (Figure 2).

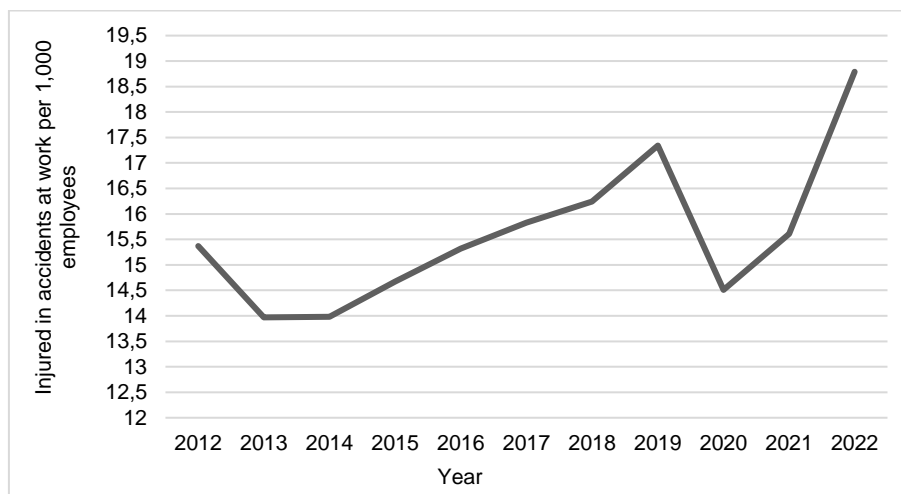


Fig.2. Injured in accidents at work per 1,000 people working in the mining industry, 2012-2022  
Source: Own work

Working in mining is one of the most difficult jobs, both in Poland and in the world (Saleh and Cummings, 2011). Mining accidents themselves are specific due to the complicated employee structure, a large number of hazards, often difficult to predict and classified in various ways (Kołęcki, 2023). Due to the alarmingly large number of accidents at work, there is a need for a detailed examination of their causes and effects (Mianowana et al., 2016), in order to implement, whenever possible, preventive actions.

### 3. CASE STUDY

In order to more clearly present the methods of investigating the causes of accidents at work, an example of a real incident from the mining industry was used. The accident in question occurred in a hard coal mine. Employee A, employed as a locksmith, started work at 6:00. He attended a meeting that day where work was divided. The meeting was led by the foreman - employee B. The manager ordered employee A to participate in cleaning works in the tower shaft tower, in one of the shafts. Employee C was also assigned to this work. During the work, without the order of the superior (employee B), the employees carried out vertical transport of elements using an overhead crane. The crane, on the order of employee A, was controlled by employee C. Employee C did not have any qualifications, he was allowed to work and trained on site by the supervisor. After completing the work, employee A, probably while closing the transport flap, was pressed against it. This event resulted in multi-organ injuries, as a result of which employee A died on the spot. When analyzing an accident, the question arises what the cause of the accident was and whether the behavior of the injured employee contributed to the accident, and if so, to what extent. To make the assessment not only subjective, the assessment method using the barrier analysis method and the TOL method were proposed.

### 3.1. BARRIER ANALYSIS

Barrier analysis is an accident investigation method that pays particular attention to malfunctioning system components that led to the accident. The analysis of barriers can be extended to the analysis of the accident context, examining the operation of the management system and human behavior (including errors). In the barrier analysis methodology, it is assumed that an accident occurs as a result of an abnormal or unexpected flow of energy, leading to uncontrolled human contact with energy exceeding the level of the body's resistance. To prevent accidents, it is necessary to place barriers between the energy source and the object that may suffer as a result of its flow (Krzyśków et al., 2015).

The concept of a barrier refers to a wide range of preventive measures used to separate the flow of energy and the resulting threat from the objects of threat (people or things). Barriers can be:

- physical or technical – created or naturally occurring structures that are intended to prevent the flow of energy or human access to a hazard;
- organizational – rules, procedures, instructions, safety policy, training or work plans that describe actions and requirements to avoid threats;
- based on the employee's knowledge or skills - various types of human behavior resulting from professional and life experience, knowledge, common sense, and education, which contribute to improving the ability to behave in hazardous conditions and make appropriate decisions.

The list of identified barriers relating to the analyzed accident at work is presented in Table 1. The most important of the identified barriers in the analyzed case were:

- closed door on floor 5 of the shaft tower;
- transport work procedure;
- the leader's responsibility resulting from his experience;
- flap technical security system.

Table 1

Barriers directly applicable to the analyzed accident at work

	Type of barrier	Barriers used
1.	<b>Physically impacting barriers</b> – prevent energy from acting or preventing an event from happening in a physical way:	
1.1.	<i>By absorbing unwanted energy or protecting it - e.g. walls, fences, barriers, balustrades, containers, tanks</i>	Closed rooms on level 5 of the shaft tower
1.2.	<i>By limiting and preventing unwanted movements - e.g. seat belts, harnesses, cages</i>	Safety harness
1.3.	<i>By protecting or separating unwanted energy from the object - e.g. crumple zones, scrubbers, filters</i>	Lack
2.	<b>Functional barriers</b> - hinder the operation of energy through technical solutions, collective protection measures that create safe working conditions:	
2.1.	<i>Preventing movements/actions (hard) – locks, interlocks, hardware adjustments</i>	Technical protection of the open cover
2.2.	<i>Preventing movements/actions (soft) – passwords, codes, fingerprints,</i>	Lack
2.3.	<i>Obstructing operation - time delay, increasing the distance (out of the employee's reach)</i>	The flap closing activation zone (link) outside the flap action range

Type of barrier		Barriers used
2.4.	<i>Energy dissipation/extinguishing – airbags, sprinklers</i>	Lack
3.	<b>Symbolic barriers</b> – correct operation requires employee interpretation:	
3.1.	<i>Countermeasure/prevention – demarcations, warning signs, signs</i>	No data
3.2.	<i>Regulatory activities – instructions, procedures, dialogue (pre-work briefing)</i>	Technology
3.3.	<i>System status indicators – signals, warnings, alarms</i>	Lack
3.4.	Permits/authorization – work permits, orders	Approval to control a crane
4.	<b>Intangible barriers</b> - correct operation requires interpretation based on appropriate knowledge:	
4.1.	<i>Implementation – procedures, rules, restrictions, guidelines, laws, training</i>	Division of labor with anterior indication
4.2.	<i>Compliance/fulfillment – restraint, ethical norms, morality, customs, social or group pressure</i>	Responsibility of the person managing the employees and the employees themselves

Source: Own work

Unfortunately, in the analyzed accident at work, all of the above barriers failed. Closing the door on floor 5 of the shaft tower turned out to be ineffective because employee A easily got into this room and worked there on the day of the accident. The available information does not clearly indicate how and by whom the above-mentioned room was made available (open door). The fact is that, despite the applicable entry ban, the above-mentioned the employee was in this room on the fateful day. This may be considered the employer's negligence, consisting in improperly securing the above-mentioned. a room classified as a closed room.

Moreover, the employer developed a procedure for operating the crane when transporting heavy elements of power-mechanical devices in the shaft tower described. This procedure specified that the brigade performing this type of work should consist of five employees, including an employee authorized to operate the crane. It is known that the order for transport work was not issued by the shift foreman of the shaft department - employee B. The work had been agreed the day before between employee A and the branch foreman of the electrical department, in a position of medium supervision, i.e. the representative of the employer, although not the direct superior of the injured party. The above-mentioned employees, contrary to the applicable procedure and bypassing the official official route, decided to perform work against the employer's recommendations. It was established that if this barrier was broken, the liability for the accident lay with both the injured employee A and the employer, because the middle manager represented the employer and acted on its behalf.

The foreman's responsibility resulting from his experience is another barrier protecting employees against the negative consequences of accidents at work. The front-runner is an experienced employee with high qualifications and professional experience. Employee A was such an employee. However, on the day of the accident, he allowed an employee without authorization to operate the crane and performed/directed, and arbitrarily ordered, transport work contrary to the procedures in force at the plant. Moreover, as tests carried out during the autopsy showed, employee A performed his work under the influence of

alcohol. The above constitutes a gross violation of occupational safety regulations and rules by the injured party.

### 3.2. TOL ANALYSIS

The method of determining Technical, Organizational and Human (TOL) causes is based on the assumption that every accident at work is caused by technical (T), organizational (O) and human (L) reasons. Accident investigation using the TOL method is carried out in a retrospective manner, based on the analysis of facts. In the TOL method, the direct cause of an accident at work is identified as an element of the course of the accident, and all actions initiating the occurrence of dangerous events or increasing the probability of their occurrence are also considered as indirect causes of the accident (Duda and Juzek, 2018). The results of the analysis of the causes of the accident at work suffered by employee A are presented in Table 2.

Table 2

Technical, Organizational and Human Causes of the accident at work suffered by employee A

Lp	Direct causes	Indirect causes	Responsible
1	Design defects of a material factor constituting a source of hazard – broken flap eye (T)	cover failure (1.1)	employer
		improper operation of a material factor (crane) (1.2)	employee A employer
2	Possibility of access to closed rooms (O)	Failure to properly secure the key or lock the level 5 door (2.1)	employer
3	Lack or improper use of a material factor by an employee (L)	Performing work manually instead of using a material factor (3.1)	employee A
		An employee making a material factor available to an unauthorized person (crane) (3.2)	employee A
4	Arbitrarily performing work without instructions (L)	Closing the transport flap independently by the injured person (4.1)	employee A
		Undertaking transport work without the order of the shaft department foreman (4.2)	employee A employer
5	Inappropriate and arbitrary behavior of an employee (O)	Passing or staying in prohibited places (5.1)	employee A employer
6	The employee's psychophysical condition does not ensure safe performance of work (O)	Working under the influence of alcohol (6.1)	employee A employer

Source: Own work

The analysis showed the occurrence of many technical, organizational and human causes related to the analyzed accident at work. Liability for the accident rests jointly with the employer and the injured employee A. In order to draw more detailed conclusions, an in-depth analysis of the TOL was performed (Table 3).

Table 3

An in-depth TOL analysis of the causes of the accident at work suffered by employee A

Lp	Indirect cause	The root cause	Responsible
1.1	Cover failure (broken ear)	Repair of the cover without the necessary documentation (welded eyelet), which did not guarantee the safety of the object, e.g. information about the material used for the eyelet, welding technology, etc., which determines the strength of the structure	employer
		Lack or improper technical inspection of the flap after repair	employer
		Lack of due diligence when inspecting a technical facility (hatch, shaft)	employer
		No marking of the damaged flap eye (the flap is out of service)	employer
1.2.	Improper operation of a material factor (crane)	Access to the crane by unauthorized persons	employer
		Allowing an unauthorized person to operate the crane	employee A
		Operation of the crane by an unauthorized person due to unauthorized performance of work	employee A
2.1	Failure to properly secure the key or lock the level 5 door	Lack of proper control over where keys are stored	employer
		No information on the number of keys	employer
		Lack or ineffective procedure for issuing keys (registry)	employer
3.1	Performing work manually instead of using a material factor	Arbitrarily performing work	employee A
		Performing work independently	employee A
		Performing work contrary to applicable procedures	employee A
3.2	An employee making a material factor available to an unauthorized person (crane)	Directing an unauthorized employee to operate a crane	employee A
		Allowing an unauthorized employee to operate the crane	employee A
		Failure to remove an unauthorized employee from operating the crane	employee A
4.1	Closing the transport flap independently by the injured person	Arbitrarily performing work	employee A
		Performing work independently	employee A
		Performing work contrary to applicable procedures	employee A
4.2		Arbitrary decision of the front man	employee A

Lp	Indirect cause	The root cause	Responsible
	Undertaking transport work without the order of the shaft department foreman	"Easy" access to the restricted zone	employer
5.1	Passing or staying in prohibited places	No complete safety barriers	employer
		Arbitrary performance of work	employee A
		Improper work performance	employee A
6.1	Working under the influence of alcohol	Insufficient supervision over the condition of employees	employer
		Employee's alcohol intoxication	employee A
		Employee misconduct	employee A

Source: Own study

#### 4. CONCLUSION

An attempt to estimate the percentage of contribution of the injured party and the employer to the accident at work is an assessment in the field of probability calculation, and the assessment presented in the article is a subjective assessment based on the identified primary causes of the event, presented in the in-depth analysis (Table 3).

The determination of the extent to which responsibility for the consequences of an accident at work should be attributed to employee A and to what extent to the employer, i.e. determining the percentage of contribution of the injured party and the employer to the accident at work, was made on the basis of responsibility for the primary causes of the analyzed accident.

In total, 27 root causes were identified, for which in 16 (59%) cases the responsibility rests with employee A, and in 11 (41%) the employer. On this basis, the liability of employee A for the accident at work resulting in his death was estimated at 59%, while the share of the employer's liability was estimated at 41%.

#### ACKNOWLEDGEMENTS

Silesian University of Technology, Faculty of Materials Engineering, supported this work as a part of Statutory Research BK-218/RM1/2023 (11/010/BK\_23/0045).

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