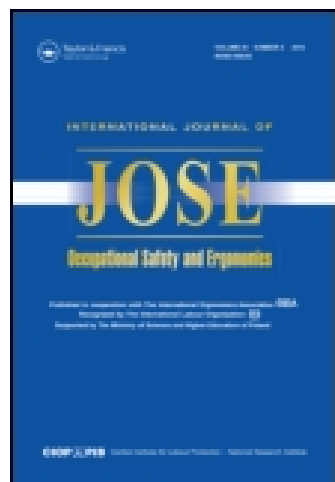


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# Safety Culture in High-Risk Industries

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*This paper addresses the question of whether adopting safety culture improves hazard prevention in enterprises characterized by high primary risk. To answer this question, sample underground coal mines were examined to investigate the basic elements of the safety culture of employees. This paper presents the results of a diagnosis of the basic elements of the safety culture of supervisors (midlevel managers) and blue-collar workers in 3 underground coal mines. The study used 2 techniques: a Likert-type scale and a questionnaire. The results indicate the need to introduce changes in the safety culture of underground coal mine employees. This study also presents the conditions for improvement. Special attention was paid to (a) the conditions for improving safety culture and (b) a programme for modifying risky behaviours.*

safety culture    risky behaviours    safety management

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## 1. SAFETY CULTURE: BACKGROUND, CONCEPTUALIZATION AND INDICATORS

Cultural conditions of safety first gained the attention and interest of academicians and practitioners of management only in the late 1980s. Thus, this is a relatively new subject with a report by the International Atomic Energy Agency on the causes of the Chernobyl accident [1] increasing its visibility. From that moment on, safety culture has been considered in investigations into the causes of other major catastrophes such as the London Underground fire at King's Cross and the explosion at the Piper Alpha drilling platform in the North Sea [2, 3]. In both these cases, the investigations of the causes strongly suggested poor safety culture.

Poor safety culture can lead to public health or occupational health problems: the Bhopal disaster involving isocyanates in India, the Fukushima disaster in Japan, the long term radiation impact of Chernobyl, the release of benzene in coking plant operations resulting in high community cancer

clusters (the fourth largest in the USA is at Clairton, near Pittsburgh, PA, the site of the world's largest coal coking plant).

In this context, the position on the safety culture of organizations has been recognized as a crucial factor in influencing the state of safety in enterprises. The development of safety culture and its practical use are two key priorities in creating safety. Pigeon suggests a definition of safety culture as (a) a system of meanings by which individuals, groups or communities understand hazard and risk and (b) a system of principles of behaviour in hazardous situations [4]. In principle, accidents are often preceded by the nonsimultaneous (or sequential) occurrence of errors in risk assessment and selection of technology, operating errors, improperly executed technical activities, mistakes of various kinds or violations of safety regulations. Any one of these issues will not necessarily lead to unwanted dangerous events, but their accumulation increases the probability of their simultaneous occurrence, which is a precondition for a catastrophe [4].

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The investigations were undertaken as part of the following projects: "Programme for limiting risks in the social subsystem of collieries" (NCBiR, NR09-0009-10/2010, 0959/R/T02/2010/10) and "Development of methods and tools for the integrated management of occupational, social and environmental risks created by major hazards" (NCBiR VIB09).

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The various definitions of safety are fundamentally similar. Two merit special attention:

Safety culture includes a set of safety-related attitudes, values, goals and behaviour patterns shared by the members of an enterprise (p. 28) [5].

Safety culture at an enterprise is a result of individual and group values, attitudes, perception, competences and behaviour patterns as well as style and quality of safety management at the organisation. A high safety culture is characterised by communication based on mutual trust, shared perception of the importance of safety and trust towards effectiveness of preventive measures (p. 16) [6].

In the UK, the definition proposed by the Health and Safety Commission in 1993 has been recognized as standard: safety culture is a “set of individual and group values, attitudes, competences and behaviour patterns determining the health and safety-at-work policy and programmes of an organisation” (p. 114) [7].

At present, two decades later, despite many theoretical studies and reports on investigations, no single definition or model of safety culture has been recognized. However, there are two main approaches. One treats safety culture like organizational culture. According to Krause’s own model based on Schein’s theory of organizational culture [8], the safety culture of an enterprise is a guide to a correct way of thinking, feeling and behaviour in relation to safety [5]. The other approach to a greater extent uses the theoretical developments in the field of safety climate and psychological theories. This approach includes Geller’s concept of safety, in which (a) the fundamental dimensions of safety culture and psychological mechanisms that make up the foundation for its development are determined and (b) it is recognized that in the process of changing safety culture, shaping safe behaviours is most important [9].

It is assumed that enterprises differ in their safety culture; each one possesses its own culture, which may be “desired” or “undesired”. This distinction indicates the existence of certain characteristics of safety culture that are correlated with a

high level of safety in the functioning of an enterprise or, alternatively, that increase the probability of catastrophes, accidents, occupational diseases or damage to property. According to Pidgeon, safety culture is made up of a system of values; attitudes towards issues of safety, hazards and risk; social standards; behavioural principles; and reflectivity in the sense that the enterprise is capable of learning on the basis of its mistakes [4].

An analysis of the indicators of safety culture of an organization makes it possible to distinguish two groups. One includes the organizational implications of safety culture: this concerns the individual aspects of a safety management system; indicators determined in the field primarily characterize the management’s safety culture. The other group comprises the characteristics of individuals, which are manifested in systems of values, attitudes, social behavioural standards and accepted behaviour patterns. Those indicators characterize the safety culture of employees at all levels, i.e., both managers and (blue collar) workers.

In later years, a series of lists of safety culture indicators was developed for specific investigations or as their result [10, 11, 12]. A review of these shows that three basic methods of empirical sociology have been used to measure safety culture.

- Case studies (including multiple-case studies) comprise holistic and embedded aspects [24]. This is a qualitative technique. When analysing an organization, its aim is to identify components of safety culture. It usually involves an in-depth questionnaire, observation and participant observation. Such investigations are typical in determining the safety culture of organizations with high accident indicators, where catastrophes have occurred [13], those with a high-risk physical working environment and, at the same time, relatively low accident indicators [14, 16], and organizations which have undergone wide-ranging changes [15].
- Comparative investigations consist in comparing characteristics of safety culture in industrial operations with high accident rates

with those with low accident rates, or departments in the same enterprise [15].

- Psychometric investigations are an increasingly popular method in identifying characteristics of safety culture. For example, UK’s Health and Safety Executive recommends questionnaires in examining workers [16]). Regular monitoring of opinions, attitudes, perceptions and behaviours of workers is common in studying the social state of the working environment [2]. For this type of investigations to be reliable, it is necessary to determine safety culture indicators for employees.

Thus far, the results of investigations have indicated that these methods ought to be complementary in investigations of safety culture, not alternative. When used together, they provide a broader look at the safety culture of an organization.

**2. DIAGNOSIS OF SAFETY CULTURE IN 3 MINES**

The basic elements of safety culture in relation to supervisors and workers were studied in three underground coal mines in Upper Silesia, Poland. The mining (physical) working environment is characterized by high primary risk resulting from the limited possibilities of controlling operations. This issue is particularly important in the context of deteriorating mining and geological conditions in underground coal mines, which result in an increase in natural hazards. This situation will

require changes in the organization of safe work. The conditions of the natural working environment influence the technical measures used and constitute a source of many hazards. Thus, workers in underground coal mines must be especially rigorous in the field of safety to maintain safe handling of operations. Section 2.1. presents the main line of investigation.

**2.1. Basic Concepts and Scope**

Based on the literature review, the following assumptions were made:

- The safety culture of a society is a factor that determines the process of managing safety within enterprises, thus ordaining the state of safety of the physical working environment (safety level of the technologies applied) and the quality of safety management systems.
- Safety culture within an enterprise is a set of individual and group values, attitudes and behaviour patterns, which determine the safety level of its employees’ behaviours.
- The safety culture of an enterprise determines the safety level prevalent within the organization both directly (through its material products) and in a mediating manner (mental layer) (Figure 1).
- In an underground coal mine, it is possible to distinguish the safety culture of high-level managers, supervisors (midlevel managers) and workers.

In this investigation, the mental and the behavioural layers were explored based on the view

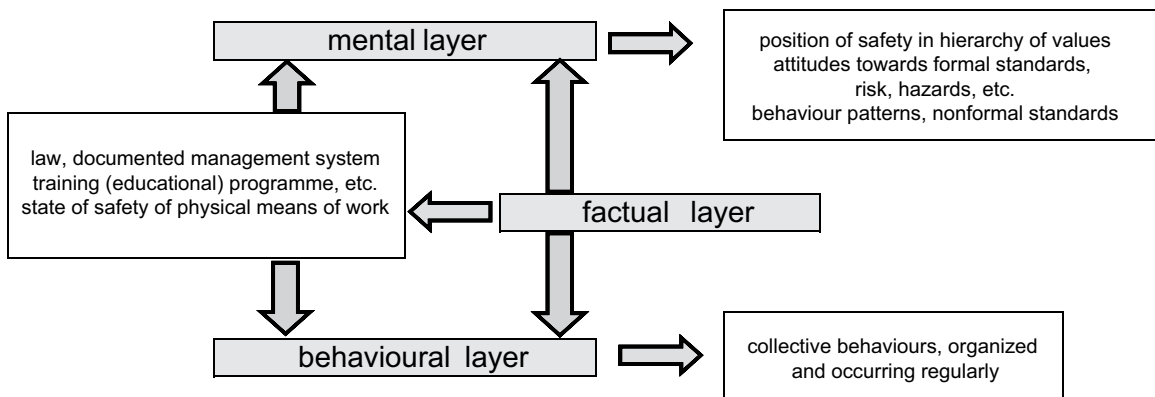


Figure 1. Layers and elements of safety culture.

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that all shortcomings in the sphere of managing an organization tend to be reflected in the employees' opinions and behaviours. This is so because the state of safety is not an isolated aspect: it is the result of a regard for occupational safety and health issues in all the operational systems of an organization. This investigation explored elements of the safety culture of underground coal mine employees: current ranking of safety in the hierarchy of work-related values, beliefs and attitudes in relation to the application of formal standards of safety, preferred and actual behavioural patterns, and the form and frequency of risky behaviours.

## 2.2. Method and Sample

The investigation was based on a questionnaire-based survey, i.e., a quantitative method commonly used in empirical sociology to collect primary data to describe a rather large population. The method of selection determined the application of corresponding tools, comprising three scales and a questionnaire. The investigation instruments described in the following sections have been used for over 10 years, also in comparative investigations, to identify changes in the state of fundamental elements of safety culture in relation to employees [17].

### 2.2.1. Work-related values: a scale

A scale of work-related values is used to determine what matters to employees. The instrument includes 10 items, selected on the basis of the literature [18] and verified with pilot tests. These are work organization, human relations, wages, promotion, improved qualifications, job security, safety at work, recognition from superiors and colleagues, attractive tasks and efficiency. Employees determine their own hierarchy in terms of safety on a 10-point scale, where 1 = *very high*, 10 = *very low*.

### 2.2.2. Attitudes towards formal standards of safety: a scale

Attitudes towards formal standards of safety can be measured with a questionnaire with positive

and negative statements on attitude and a Likert-type scale [19, 20]. Individuals adopt an attitude towards each statement by determining the degree to which its contents reflect their beliefs. The scale comprises nine positive and nine negative statements, selected from a list of 48 items obtained during interviews with workers in underground coal mines. The selection followed pilot tests with 120 employees in underground coal mines. The inclusion of a given statement in the final version of the scale was based on an evaluation of the degree of significance of the difference between the mean score of each item separately for the group with a high general score and the group with a low general score using Student's (Gosset's) *t* test [20]. The indicator of attitude is the mean of assigned points: 1–2 = negative attitude; 2.1–3.9 = ambivalent attitude; 4–5 = positive attitude. Moreover, attitudes were divided into five groups determining the regulatory functions of formal standards, i.e., stimulation of work effectiveness, regulation of work content, recognition of legitimacy of obstacles making application of regulations difficult, regulation of work safety, and stimulation of employees' behaviours.

### 2.2.3. Behaviour patterns: a scale

The scale of behaviour patterns [21] evaluates the degree of divergence between the behaviour patterns preferred by employees and those of the behavioural model. It is composed of five employee profiles ranging from A = *fully compliant with formal standards of safety* to E = *completely noncompliant with formal standards*. Each profile is assigned a score, where A = 1 and E = 5; the higher the score, the greater the departure from the model's safe behaviours. In selecting a profile, the respondents determined the actual pattern at their enterprise and a desired pattern, featuring an employee working effectively and safely.

### 2.2.4. Questionnaire

A questionnaire was used to determine the frequency of engagement in risky behaviours. It covered 52 risky behaviours of underground coal

mine workers which, in earlier investigations, were determined by supervisors as the most frequent in their mines. The respondents reported how often they had observed each risky behaviour during the past year: 1 = *very often*; 2 = *often*; 3 = *sometimes*; 4 = *seldom*; 5 = *sporadically*; 6 = *never*. The percentage of observers who perceived a specific behaviour as undertaken *very often*, expressed as the mean frequency of undertaking each risky behaviour, was the indicator.

### 2.2.5. Sample

The formula for indispensable sample size ( $n_b$ ) for an unchanging value in the estimated fraction was used to calculate the size of the sample. The maximum value of the sample was assumed, e.g., 25% [20]. Thus, the number of persons included in the sample depended on the number of supervisors and workers in an underground coal mine. The sizes of samples calculated for the selected mines were as follows:

mine 1: supervisors 214, workers 337;  
mine 2: supervisors 230, workers 334;  
mine 3: supervisors 203, workers 341.

The mines differed in hazards, machinery and accident rates. The numbers of accidents per 1000 employees, recorded in each underground mine in the 3 years prior to the study, were as follows:

mine 1:  $M$  26.7, range 21–30;  
mine 2:  $M$  13.0, range 8–20;  
mine 3:  $M$  11.3, range 11–12.

The same company operated underground coal mines 1 and 3, another one operated mine 2.

## 3. RESULTS

The investigation took place in 2011; it provided rich empirical data on the mental and behavioural layers of the safety culture of underground coal mine employees. This paper presents the results of an assessment of two groups of employees (underground coal mine supervisors and workers) in three mines with respect to the following indicators: the ranking of safety in the hierarchy of work-related values of supervisors and workers;

attitudes towards the application of formal safety standards; evaluation of regulatory functions of formal safety standards; behaviour patterns preferred by employees; and the frequency of engaging in risky behaviours. More extensive data on supervisors only have been discussed elsewhere [25].

### 3.1. Hierarchy of Work-Related Values

In the three underground coal mines, safety appeared to be most important for over 10% of supervisors and workers. The highest percentage of employees assigning the top rank to safety was recorded at mine 3, whereas the lowest at mine 1 (Table 1).

**TABLE 1. Underground Coal Mine Employees Who Recognize Safety as a Priority (1 in the Hierarchy of Work-Related Values) (%)**

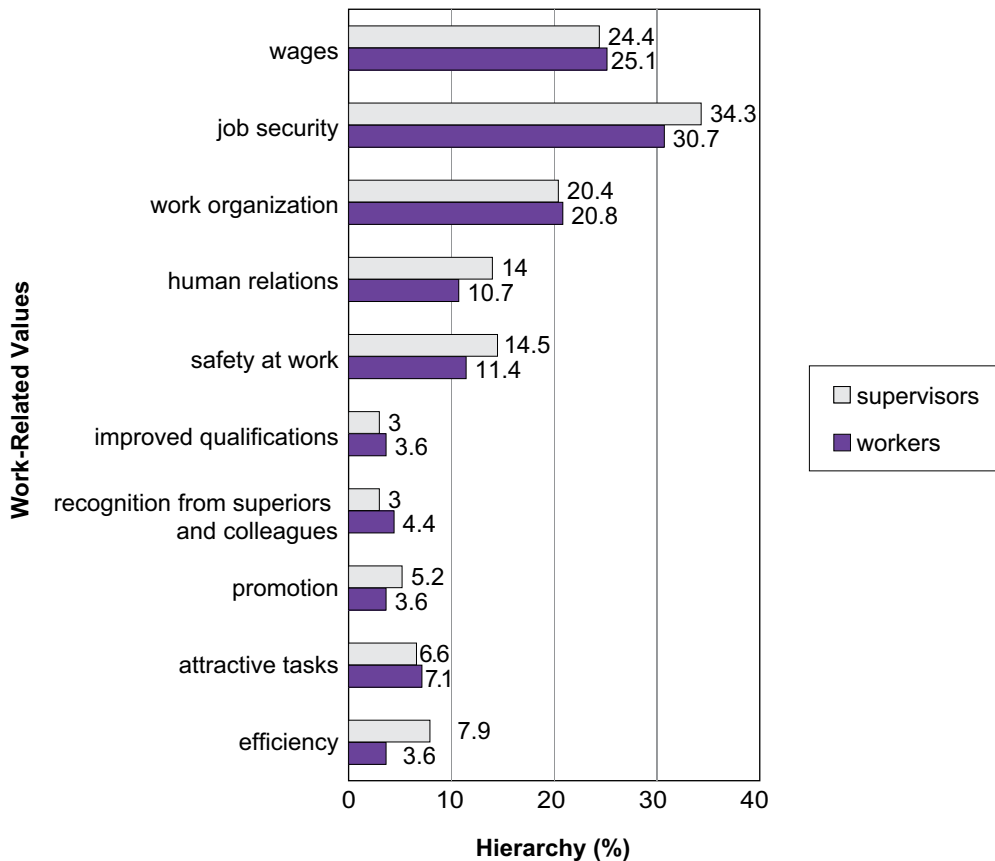
Mine	Supervisors (%)	Workers (%)
1	6.4	3.6
2	13.2	8.3
3	14.5	11.4

*Notes.* Mine 1: supervisors  $n = 172$ , workers  $n = 225$ ; mine 2: supervisors  $n = 202$ , workers  $n = 234$ ; mine 3: supervisors  $n = 193$ , workers  $n = 219$ . In analysing operations, statistically significant differences were considered, i.e., the ranking of safety in the hierarchy of work-related values of supervisors and workers for mines 1 and 2, mines 1 and 3, mines 2 and 3 (Mann-Whitney  $U$  test,  $p < .05$ ).

The results suggest that for at least 85% of supervisors and 88% of workers, safety was less important than wages, work organization, job security or, at one underground coal mine, human relations. Thus, in the three mines, safety seemed to be a priority only in the policy on safety. In a conflict situation, when it is necessary to choose between values, safety ought to be considered a priority. Figure 2 presents the results.

### 3.2. Attitudes Towards Application of Formal Safety Standards

The term “attitude” denotes opinions, feelings and reactions manifested by a person relative to other people, objects, events and phenomena. An attitude may be positive, negative or ambivalent, and strong or weak; emotional and evaluative components are necessary for it to come into



**Figure 2. Hierarchy of work-related values of underground coal mine employees from 3 mines (maximum percentage of rank 1 choices).**

existence, but other elements need not be present [22]. Thus, whether or not a behaviour has characteristics of an attitude also depends on other factors, e.g., personality-related factors (other attitudes held that are contradictory, motives that are contradictory to attitude, social skills, etc.) and situation-related factors (presence of important persons with different attitudes, regulations on roles, existence of alternative behaviours, predicting consequences of behaviours, etc.).

In relation to the opinions and views of underground coal mine employees found in the three mines that inform on the acceptance or rejection of regulations, procedures and instructions, it is necessary to decide what rank should be assigned to the attitudes in relation to applying safety standards. Table 2 shows that ~21% to ~36% of supervisors and ~15% to ~24% of workers had a positive attitude, whereas ~13% to ~14% of supervisors and ~14% to ~18% of workers had a negative attitude.

The beliefs and opinions of underground coal mine employees on the application of regulations, procedures and instructions were classified into five groups characterizing five regulatory functions of formal standards. Table 3 shows percentages of respondents who provided positive evaluations. Underground coal mine supervisors and workers at each mine tended to evaluate formal standards most positively in relation to the aspect of regulation of work content (supervisors 61%–67%; workers 47%–52%). The role of standards in regulating work safety was evaluated positively by 47%–54% of supervisors and 41%–50% of workers.

The results of the questionnaire on the application of formal safety standards showed that too great a percentage of employees were critical towards the application of regulations, procedures and instructions. The relatively low percentage of those with a positive attitude towards formal standards in relation to the regulation of work safety is particularly alarming.

**TABLE 2. Attitude of Underground Coal Mine Employees Towards the Application of Formal Safety Standards**

Attitude	Mine 1		Mine 2		Mine 3	
	Supervisors	Workers	Supervisors	Workers	Supervisors	Workers
negative	13.7%	17.1%	14.4%	18.0%	13.2%	13.6%
positive	21.3%	15.5 %	25.8%	21.4%	36.2%	23.9%

Notes. Mine 1: supervisors  $n = 196$ , workers  $n = 306$ ; mine 2: supervisors  $n = 194$ , workers  $n = 217$ ; mine 3: supervisors  $n = 203$ , workers  $n = 340$ . In analysing operations, statistically significant differences were considered for supervisors and workers in mines 1 and 3 ( $t$  test,  $p < .05$ ).

**TABLE 3. Evaluation of Regulatory Functions of Formal Safety Standards**

Regulatory Functions	Employees <sup>a</sup> Providing Positive Evaluations (%)					
	Mine 1		Mine 2		Mine 3	
	Supervisors	Workers	Supervisors	Workers	Supervisors	Workers
Stimulation of work effectiveness	46.3	37.7	45.9	38.9	47.4	41.1
Regulation of work content	57.7	47.1	62.9	46.9	67.1	51.5
Regulation of work safety	43.9	42.2	47.3	43.3	54.4	49.5
Recognition of legitimacy of obstacles hampering application of regulations	31.0	20.0	32.1	26.2	39.1	22.3
Stimulation of safe behaviours among supervisors	33.5	—	36.2	—	41.2	—

Notes. a = underground coal mine employees. Mine 1: supervisors  $n = 196$ , workers  $n = 306$ ; mine 2: supervisors  $n = 194$ , workers  $n = 217$ ; mine 3: supervisors  $n = 203$ , workers  $n = 340$ . In analysing operations, statistically significant differences were considered ( $t$  test,  $p < .05$ ): (a) supervisors in mines 1 and 3, mines 2 and 3—regulation of work safety and recognition of legitimacy of obstacles hampering application of regulations; (b) supervisors in mines 1 and 3—stimulation of safe behaviours among workers; (c) workers in mines 1 and 3, mines 2 and 3—stimulation of work effectiveness, regulation of work content, regulation of work safety; (d) workers in mines 1 and 2, mines 2 and 3—recognition of legitimacy of obstacles hampering application of regulations.

### 3.3. Preferred Behaviour Patterns

Each community, including employees of an organization, adopts certain behavioural patterns recognized as normal in a given situation, or a range of behaviours, and knowledge of such patterns makes it possible to predict their behaviour. Knowing behaviour patterns—those desired and actual, effective and safe—has made it possible to assess the acceptability of different degrees of departure from a model pattern (i.e., the formal standard) of the behaviours preferred by supervisors and workers in the three mines (Table 4).

The highest degree of conformity to the model pattern, characterized by slight departures from it, is represented by desired patterns (83%–94% of supervisors; 78%–89% of workers) and patterns illustrating safe work (83%–87% of supervisors; 76%–92% of workers).

### 3.4. Frequency of Undertaking Risky Behaviours

Risky behaviours are regarded as the behavioural implications of safety culture. In this investigation, it was assumed that risky behaviours were those noncompliant with behaviours in safety regulations, procedures and instructions. In Table 5, of the 52 behaviours included in the questionnaire, we include risky behaviours reported as observed particularly often and by the highest percentage of supervisors (over 20%).

Table 5 shows that risky behaviours were most common in mine 1. This has been confirmed by calculating the means for each of the 52 risky behaviours included in the instrument; there are only slight differences between the means calculated for all behaviours in common—mine 3 appeared to have the best indicator, whereas mine 1 the worst (Table 6).



TABLE 4. Behaviour Patterns Preferred by Underground Coal Mine Employees in 3 Mines

Pattern	Preferred Model Patterns and Patterns With Slight Departure From Model (%)						Accepted Maximum Departure From Model (%)	
	Mine 1		Mine 2		Mine 3		Supervisors	Workers
	Supervisors	Workers	Supervisors	Workers	Supervisors	Workers		
Desired	82.6	78.0	90.9	89.2	93.9	81.1	11.3	11.2
Actual	44.6	33.0	48.4	45.8	57.5	39.9	12.9	12.8
Safe	83.4	75.9	86.4	91.5	87.2	74.1	3.8	8.1
Effective	58.0	54.8	68.0	65.7	64.5	55.2	10.0	10.9

Notes. Mine 1: supervisors  $n = 195$ , workers  $n = 301$ ; mine 2: supervisors  $n = 191$ , workers  $n = 218$ ; mine 3: supervisors  $n = 219$ , workers  $n = 318$ . In analysing operations, statistically significant differences were considered ( $t$  test,  $p < .05$ ): (a) supervisors in mines 1 and 2, mines 2 and 3—patterns performed; (b) supervisors in mines 1 and 2—patterns effective; (c) workers in mines 1 and 2, mines 2 and 3—patterns desired, actual, safe, effective.

TABLE 5. Risky Behaviours of Workers Observed by Supervisors

Risky Behaviour	Mine <sup>a</sup>
Moving along haulage ways inconsistently with regulations	1, 2, 3
Lack of discipline during descent and ascent of employees	1, 2, 3
Staying and moving on haulage ways during transport operations	1, 2
Wrong storage of materials in mine operations	1
Manual rolling of heavy devices and materials	1
Use of wrong tools	1
Travelling on a conveyor not adapted to carrying people	1
Crossing a conveyor where not allowed	1
Performance of service activities on active devices	1, 3
Working at large heights without safety devices	1

Notes. a = mines in which a behaviour was observed *very often* and *often* by >20% of supervisors. Supervisors in mine 1:  $n = 194$ , mine 2:  $n = 10$ , mine 3:  $n = 219$ .

TABLE 6. Mean Frequency of Risky Behaviours

Mean Frequency	Risky Behaviours Observed at Specified Frequency		
	Mine 1	Mine 2	Mine 3
$\leq 2.0$	0	0	0
>2.0–3.0	3	2	0
>3.0–4.0	27	28	23
>4.0	22	22	29
$M^a$	3.8	4.0	4.1

Notes. a = mean for 52 behaviours.

#### 4. CONDITIONS FOR CHANGING SAFETY CULTURE

Is it possible to change safety culture through purposeful action? Experts disagree on this and nobody has succeeded in presenting arguments strong enough to support their hypotheses. The theoretical arguments and empirical data presented thus far indicate that in trying to make a purposeful change in safety culture, it is neces-

sary to consider the levels of the safety culture of society, industry, specific organizations and individuals.

In practice, introduction of a change in safety culture depends on manipulations of diverse organizational characteristics that have an impact on the effectiveness of managing an enterprise as a whole and managing its safety. Here, the term “manipulation” refers to activities oriented towards achieving specific objectives [23]. Thus,

it is necessary to define objectives and the conditions for their attainment.

Locke and Latham’s theory of goal setting and Bandura’s model of reciprocal determinism were considered in a programme of forming safety culture at an enterprise by achieving changes in the behaviour of employees [17]. The basis of the programme was constructed based on the assumption that the safety level of employees’ behaviour is a function of possibilities and motivations. Possibilities involve organizational aspects, facilitating undertaking safe or risky behaviours (effectiveness of safety management systems, work organization), and subjective factors, i.e., competences of employees, professional and relating to safety (knowledge of procedures, relevant risk assessment, ability to control hazards, talents, skills, personality). Motivations for undertaking safe behaviours involve internal necessity to undertake behaviours conforming to the requirements of formal standards (resulting, e.g., from the high rank of safety in the individual hierarchy of values), attitudes towards hazards, risk and formal safety standards, preferred behaviour patterns (Figure 3).

The behavioural function has a multiplicative character, which means that to be successful in preventative activities it is important to cover simultaneously both the spheres of possibilities and motives (without motivation to act safely, employees will not behave safely regardless of their high qualifications).

The programme for changing safety culture by limiting employees’ risky behaviours, developed at the Central Mining Institute (Katowice, Poland), consists of three parts:

- Diagnostic measures involve gaining knowledge of hazards produced by the so-called human factor; they result in an exploration of the content, frequency and causes of workers’ risky behaviours (procedure of identifying risky behaviours and their causes).
- Preventive activities are based on the results of cognitive tests of risky behaviours; activities are aimed at improving performance in relation to factors of safe behaviour determined through cognitive tests, those factors being motivation (elimination of behaviours resulting from risks consciously undertaken and group standards which are in conflict with formal standards), qualifications (elimination of behaviours resulting from no knowledge or skills), work organization (elimination of behaviours caused by shortcomings in work organization) (procedure for modifying risky behaviours);
- Supportive measures comprise promotional activities that affect the formation of a value system and influence the attitudes of employees (programme for promoting safety). Thus, the procedure for identifying risky behaviours and their causes allows problems in the social environment of work to be identified, e.g., what shortcomings in work organization produce conditions that make workers more prone to undertaking risky behaviours, whether or not the training system provides workers with indispensable knowledge and skills, and whether or not there are risky behaviours in underground coal mines that derive from obligatory group

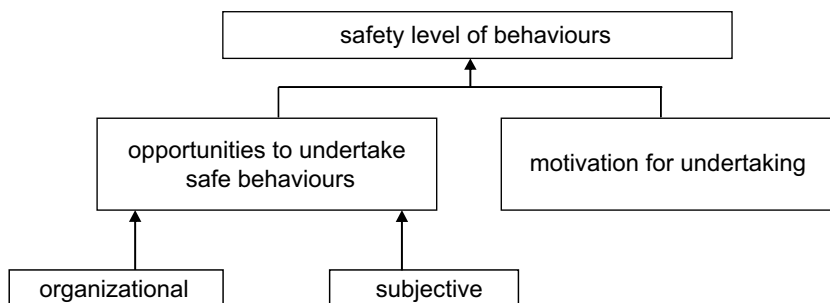


Figure 3. Conditions of undertaking safe behaviours (p. 339) [26].

standards or deliberately undertaken risk. The causes of identified risky behaviour constitute in turn a basis for determining detailed objectives and activities allowing the attainment of risk abatement measures (procedures for modifying risky behaviours), and with time also the overall goal of ensuring sound safety culture.

The investigations performed thus far have shown that the behaviours of workers reflect numerous shortcomings in relation to the management of their organization as a whole. Achieving changes in their behaviours requires the specific causes that produced them be eliminated. This may be accomplished through activities aimed at removing the shortcomings in improperly functioning subsystems. As a result, in activities designed to achieve the overall goal, there will be those that simultaneously aim at producing changes in the working environment and changes in the attitudes and characteristics of individuals in the behavioural context.

## 5. SAFETY CULTURE IN PREVENTING HAZARDS: A MILESTONE OR NONSENSE?

The direct reason for attempts at finding new solutions in work safety is no acceptance of current accident rates in underground coal mines, which are often interpreted as a result of improperly functioning safety management systems. This does not mean that during their operation the accident rate has not decreased or other accident indicators have not improved. This rather indicates that the systems have achieved their potential and reached their limit; thus, it is necessary to make sequential qualitative changes to achieve further progress.

The causes of accidents have directed the attention of practitioners in work safety to the social subsystem of their enterprise, mainly the role of employees in the maintenance of safety levels and improvements in prevailing safety standards. The results of our investigations into the mental and behavioural elements of safety culture obtained from three underground coal mines in

2011 seem to confirm the pertinence of the new trend in and focus on activities that should prevent accidents. We have shown that

- a low percentage of underground coal mine employees value safety highly: depending on the mine, few employees (based on percentages) assigned first place to safety in the aggregated hierarchy of work-related values;
- a low percentage of underground coal mine employees have a positive attitude towards the application of formal safety standards;
- there is considerable divergence between model patterns and patterns that are performed and regarded as effective.

Moreover, the many types of risky behaviours that workers in underground coal mines engage in, their frequency and potential effects justify categorizing them as highly risky. As discussed earlier, the results of the study on the safety culture in underground coal mines indicate that (a) safety is not a priority among underground coal mine employees, and (b) both supervisors and workers are mostly ambivalent towards the application of formal safety standards. Moreover, a high percentage of underground coal mine workers often fail to recognize risky patterns of behaviour. Thus, workers, in the opinion of supervisors, engage in risky behaviour patterns. In line with the frequently articulated views for improving the position on safety, these facts indicate that there is a need to make changes in the awareness of employees in mines. This is confirmed by the results of the analysis of mental and behavioural characteristics in relation to the safety culture of supervisors and also workers in underground coal mines. Thus, changes are necessary in the social subsystem of underground coal mines.

A question yet to be addressed is whether the application of the concept of a safety culture will really improve in practice safety in underground coal mines and determine the success of activities that should prevent accidents. The adoption of the concept of safety culture and its implementation, e.g., a programme for modifying risky behaviours of employees in underground coal mines, would not introduce qualitatively

new preventive activities but would orientate existing ones towards achieving the overall goal of producing positive changes in the safety culture of employees in mines. Success in this regard seems to depend on the determination of the top-level managers because achieving changes in the behaviour of workers is conditioned by improvements in the functioning of many subsystems of an enterprise, including the social subsystem, mainly in the field of improving occupational and work-safety-related competences as well as the motivation of employees to engage in safe behaviours.

The fact that this is possible is confirmed by the achievements at one of the underground coal mines of Southern Coal Concern (Poland). Two years after the introduction of an employee behaviour modification programme and without profound changes in the organization of work, the mine was able to reduce the accident rate per 1000 employees by half. Comparative studies on the safety culture of the crew of the mine will take place in the future.

Can this concept of safety culture in the prevention of risks be considered a milestone? This is perhaps premature, but certainly promising.

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