

## OCCUPATIONAL RISK ASSESSMENT IN MANAGEMENT OF HEALTH AND SAFETY IN WORKPLACES

### Key words:

hazards, occupational risk assessment, preventive controls measures, occupational, health and safety management system

### 1. Chosen legal requirements on risk assessment

Basic principles related to occupational health and safety (OH&S) arise from the international, European and national legal standards.

The central standard, which provides guidance for actions at national and enterprise level to promote occupational health and safety, and to improve the work organization and working environment is the ILO Convention 155. It provides that *each Member shall (...) formulate, implement and periodically review a coherent national policy on occupational safety, occupational health and the working environment* [14], and that the fundamental aim of the policy is to prevent accidents and injuries to human health by eliminating or minimizing the causes of hazards present in the working environment.

Within the European Community the best-known document, called the framework directive, is Council Directive 89/391/ECC on the introduction of measures to encourage improvements in the safety and health of workers at work. According to this one of the main obligations of each employer is to “take the measures necessary for the safety and health protection of workers, including prevention of occupational risks and provision of information and training, as well as provision of the necessary organization and means” [15]. Measures should refer especially to avoiding the risks, evaluating and monitoring the risks which cannot be reduced and eliminating the risks at source.

In Poland, OH&S requirements and standards are based largely on the Labour Code and related regulations. By Article 226 of the Labour Code, each employer is, in particular, obligated to [17]:

- evaluate the occupational risk in workplaces,
- provide workers with appropriate protective measures,
- inform workers of any occupational risk connected with their work and of the rules for protection against hazards,
- document the results of risk assessment.

In order to help organizations improve their OH&S performance and become more efficient in reducing occupational risk in the workplaces, the guidance documents, specifications and standards have been developed – Figure 1.

In 1996, the British Standards Institution published the standard BS 8800 on the management of health and safety in the workplaces. Next, in

response to a high market demand, the series of international standards OHSAS 18000 was developed. The OHSAS series consists of three parts:

- OHSAS 18001: *Occupational Health and Safety Management Systems. Specification* (last update in 2007), which includes requirements for organizations how to establish, implement, maintain and continually improve the OH&S management system. If an organization will prove that its health and safety management system complies with the requirements of OHSAS 18001 standard, it may undergo independent assessment and achieve certification to OHSAS 18001.
- OHSAS 18002: *Occupational Health and Safety Management System. A guide to occupational risk assessment.*
- OHSAS 18004: *Occupational Health and Safety Management System. Guidelines for the implementation of OHSAS.*

OHSAS 18001 is globally recognized standard and has been used in many countries worldwide.

In Poland, the similar standard and guides related to occupational health and safety management systems have been developed in: PN-N-18001, PN-N-18002 and PN-N-18004. Polish companies can be certified in health and safety good practices to both OHSAS 18001 and PN-N 18001. The basis for the both standards is the Deming cycle, a concept also known as PDCA model.

At present, ISO is developing a new International Standard for Occupational Health and Safety Management Systems ISO 45001 (to be published in late 2016) which determines requirements for OH&S management system in companies and organizations around the world. It is based on the OHSAS 18001 and uses the same common structure, terms and core text as the quality and environmental management system standards. ISO 45001 will be introduced in October 2016 to replace OHSAS 18001, and it will be better aligned with ISO 9001 and ISO 14001 [5] (Fig. 2).

The occupational health and safety standards aim at providing companies with the elements of an efficient OH&S

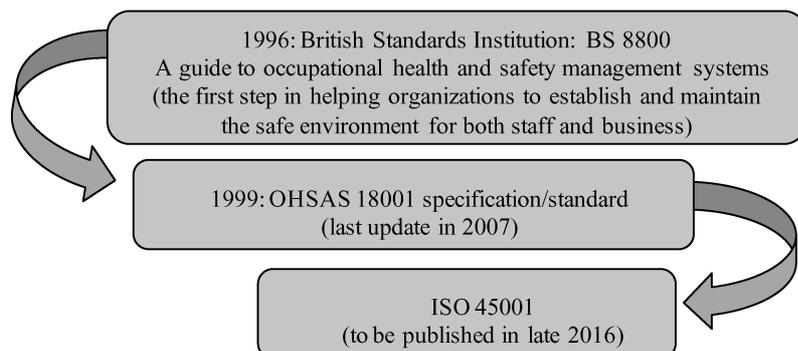


Fig. 1. Development of health and safety management systems



Fig. 2. Integration of main management systems in a company

management system, which may be integrated with other management demands, and consequently, they enable organizations to obtain their OH&S and economic objectives.

## 2. Risk management process

### 2.1. Occupational hazards and risk

A hazard is often expressed as “a source of potential harm or a situation with a potential to cause loss” [3]. Therefore, an occupational hazard is anything that has negative and unwanted impact on human health and life. An occupational risk is workplace related and may affect employees in the work environment, and may result in an injury, fatality or other health issues [3].

A risk determines the uncertainty about a situation, which may lead to an accident or adverse health effect on people at work. The uncertainty is described by likelihood or probability. These terms are often used interchangeably, but there is a difference between them. In colloquial, the uncertainty is determined by terms likelihood or chance and the qualifying adjectives are used to define its extent (e.g. most unlikely, highly likely). In contrast, in mathematics, the uncertainty is described by term probability and is a number between 0 (impossible) and 1 (certainty) [13]. Consequences are always adverse, unwanted and negative, and may range from almost inconsequential to absolutely massive [13]. They may range from a minor discomfort to serious injury or fatality. Then, a risk is the function of probability of occurrence (uncertainty, P) and severity of consequence (adverse effect, C):

$$R = f(P, C)$$

Occupational risk arises from the exposure of the employee to the hazards present in the workplace. Thus, a probability (P) depends on relative frequency of occurrence of undesired event, level of exposure compared to occupational exposure limit, frequency and duration of exposure, as well as on quality of control measure which increase the possibility to avoid hazardous situation [1]. So:

$$R = f(F, E, A, C)$$

where:

F – frequency of appearance,  
E – exposure (defined as the frequency and/or duration of exposure to the hazard, may range from very rare to continuous),  
A – possibility of avoidance of a hazard.

Systematic and ongoing risk management process enables employers to identify hazards and implement measures, and thereby to eliminate or control the risks. So, it is important to carry out the risk management process comprising a coordinated set of activities, methods and techniques which involves, in particular, establishing management policy, procedures and practices, identifying, analyzing, evaluation and treating the risk, as well as monitoring and communicating the risk to all engaged in the company activity – Figure 3.

Risk analysis is the process of recognizing hazards and determining related undesired events with the careful consideration of probability of their occurrence and potential impact for employees' health. Risk assessment provides the objective hazard measures and allows to categorize the risk level. It is clear that risk management tasks and duties are imposed on each employer. In medium and large companies the risk assessment should be conducted by a multidisciplinary team who have a proper knowledge of the work. The team approach is best adopted comprising representatives of various levels and areas in the company [1]. Therefore, the risk assessment team in a production company should include representatives of managerial staff and supervisors, process engineers, maintenance personnel, safety staff and experienced production operators.

### 2.2. Hazards identification

Each employer is responsible for providing safe work-systems in which employees will feel safe and will be effectively prevented from being harmed. Hazards are present in any workplace, and that is why each employer should protect workers against hazards they may be exposed to. In general, the aim of this step is to recognize all possible hazards that may be present in workplace.

In a workplace, described as the man-machine system (Fig. 4), the sources of hazards can be:

- materials and substances,

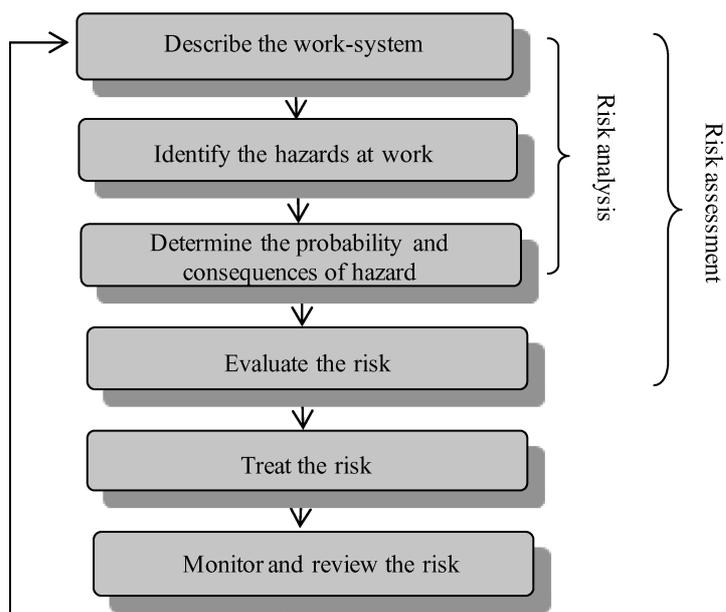


Fig. 3. Main stages in risk management process (based on [16])

- energy used,
- processes and tasks performed,
- work methods and organization,
- machinery and equipment,
- other people (e.g. supervisors, subordinates, co-workers, clients, visitors),
- premises and material environment (e.g. location, traffic routes, lighting).

A helpful tool providing information on a health and safety in workplace is the job description, which provides the data on tasks and operations – their order, frequency and a way they are performed, on used materials, energy, equipment and tools, location, work run process, as well as relationships with other persons.

Occupational hazards can be divided into many categories according to their nature and the way they can cause harm – Figure 5. In general, hazards may be a source of accidents leading to physical harm of worker’s body, as well as they may lead to the development of industrial disease or other adverse health effect.

To identify the hazards some methods and techniques may be used:

- reviewing information from designers or manufacturers,
  - reviewing information from material or product suppliers (to find more about used materials and how they affect health and safety, the Safety Data Sheet is useful, it is a document attached to a product and contains, above all, information on the main hazards connected with chemicals, exposure controls and protective measures, safe handling and storage rules)
  - reviewing measurements for environmental factors (e.g. quantity level of noise or vibration, chemical gases and dust compared to the occupational limits),
  - talking and consulting with employees,
  - reporting and analyzing the work process,
  - conducting regular direct inspection of workplaces and walk-through surveys (watching what workers do and how they do it),
  - analyzing the data on job-related illnesses, accidents, near-miss incidents,
  - developing the hazard checklists,
  - seeking an advice from health and safety professionals.
- Information gathered about the work systems is a core input to risk assessment.

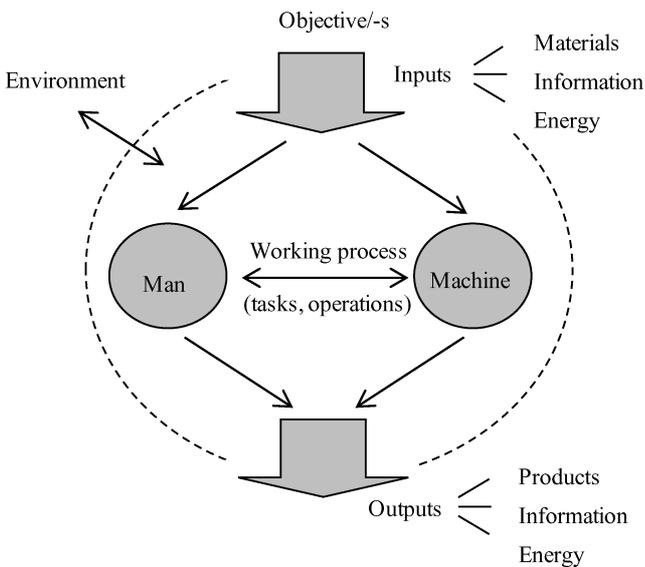


Fig. 4. Components of the man-machine system

**2.3. Risk analysis and assessment**

After listing the occupational hazards, the next step is to determine what kind of adverse health effects could result from the exposure and how serious would they be. An example of risk analysis is shown in Table 1.

During the risk assessment process hazards are prioritized and compared against predetermined standards in order to evaluate their level of risk and decide whether the specified risk level is acceptable or not. The aim of risk evaluation is to make decisions about risk treatment activities and about the priority for treatment implementation.

The assessment should be reviewed periodically, e.g. annually, or, when a change is introduced to the work system (a change in material, equipment, work method, etc.), as soon as possible.

**2.4. Risk assessment methods**

There are a plenty of methods and techniques used to compare risk analysis outcomes with risk criteria and to assess

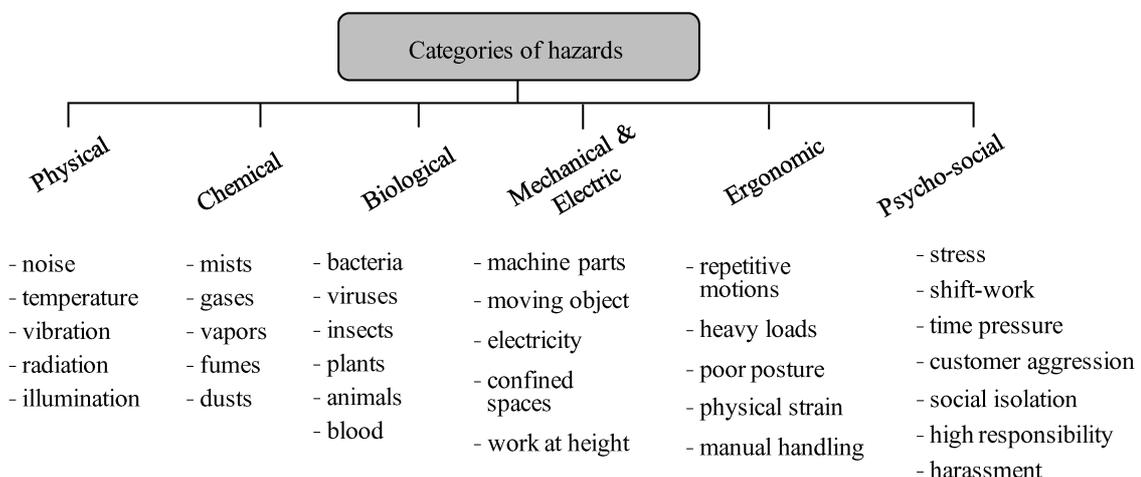


Fig. 5. Categories and examples of hazards

Task	Hazard source	Hazard	Possible consequences	Likelihood
Fastening and unfastening of materials	Manual material handling	Excessive or incorrect lifting and carrying	Musculoskeletal disorders (spine-ache, pain in upper limb, muscular and back strain, slipped disc)	How often have incidents linked to the particular hazards been occurring?  How long a worker is exposed to a hazard?
		Bending and turning	Back pain	
		Heavy loads	Muscular overexertion, strains	
		Falling objects	Being hit, hurt (fractures, bruises)	
Operating universal lathe	Machinery and tools	Sharp tools	Being hurt (cuts and bruises)	
		Moving parts	Being crushed/caught between/squashed (fractures, dislocations, permanent injuries, death)	
		Noise	Chronic health problem (heart, stomach and nervous disorders), hearing damage	
		Whole-body vibration	Fatigue, headache, stomach problems	
		Electricity	Shock, electrocution	
Metal processing	Hazardous substances	Shavings and dust	Skin/eye damage, eye irritation	
		Metal fumes	Headaches, nose/respiratory irritation	

Tab. 1. Risk analysis – examples

the risk level. They vary from qualitative to quantitative approaches [11].

Quantitative risk assessment (QRA) is conducted on the basis of statistical data on quantity and types of accidents at work, work-related illnesses and other dangerous events. The risk is estimated numerically. Quantitative approach is addressed, in particular, to high technology enterprises (e.g. gas, chemical or nuclear industries), where it is used to assess reliability and safety in technological processes [2].

In qualitative approach the assessment is based on judgments of persons involved in assessment process, that is why it is regarded as more subjective. Likelihood and consequence, as well as the risk, are estimated with the use of pre-determined relative scales. The risk is classified in terms, e.g. Low, Medium/Moderate, High.

The question is, which method best suits the needs of a company. The approaches have both advantages and limitations, however the solution is not finding an ideal method, but the most appropriate from the viewpoint of company's conditions and experiences of members of the assessment team. In many situations a qualitative scheme is sufficient. Mainly, because the process is quicker to complete, requires less time and is less costly, provides findings simple in nature and sufficient to understand and compare the risk, and to take adequate control measures. This type of assessment is used especially when numerical data are unavailable, resources (budget or expertise) are limited and time allowed is reduced [9]. There are also some reasons for not quantifying a risk assessment [2]. Quantitative analysis requires the reliable data. It needs more training to handle functions, like statistics, uncertainty analysis, graphics interfaces and mathematical and simulation tools. Quantitative analysis is far more time consuming and costly method. Hence, qualitative approaches are more common in use than pure quantitative due to time and cost involved (Fig. 6).

Risk matrices are one of the most popular qualitative methods of risk assessment. They have

two dimensions of assessment: likelihood and severity, and the combination of them enables to place an event on a risk matrix. The 3x3 matrix is included in PN-N-18002 (*Occupational Health and Safety Management System. General guidelines to occupational risk assessment*) and is recommended to apply in Polish companies. The risk may be evaluated in three-level scale (Low, Medium, High) or five-level scale (Very Low, Low, Medium, High, Very High) [16]. If possible, it is recommended to estimate the risk on the basis of the values characterizing the hazard, in particular, for measurable factors, for which the occupational exposure standards have been predetermined and included in regulations relevant to health and safety. Examples of such measurable hazards are noise, vibration, radiation, dust and fumes. The risk is evaluated as a high if the measured value characterizing the worker's exposure exceeds the permissible limit. The general guidelines of assessing the occupational risk in the three-level scale for hazards with measurable exposure values are presented in PN-N-18002.

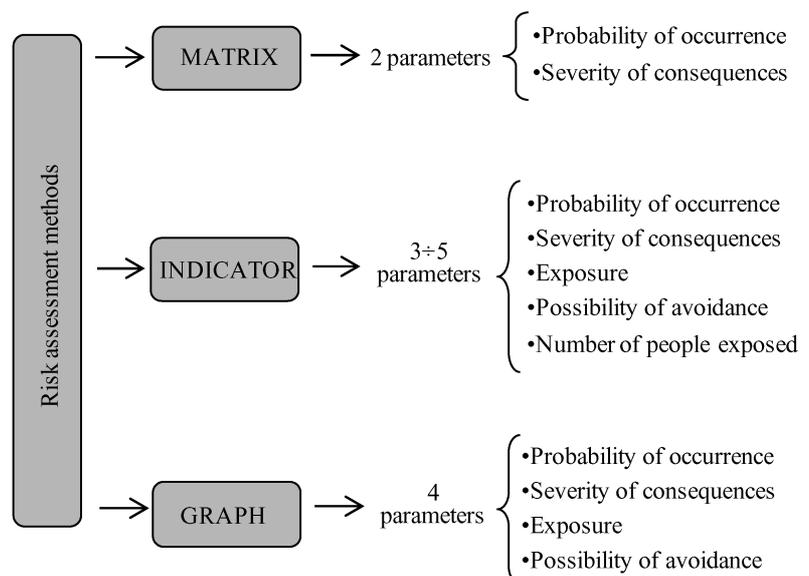


Fig. 6. Types of qualitative risk assessment methods



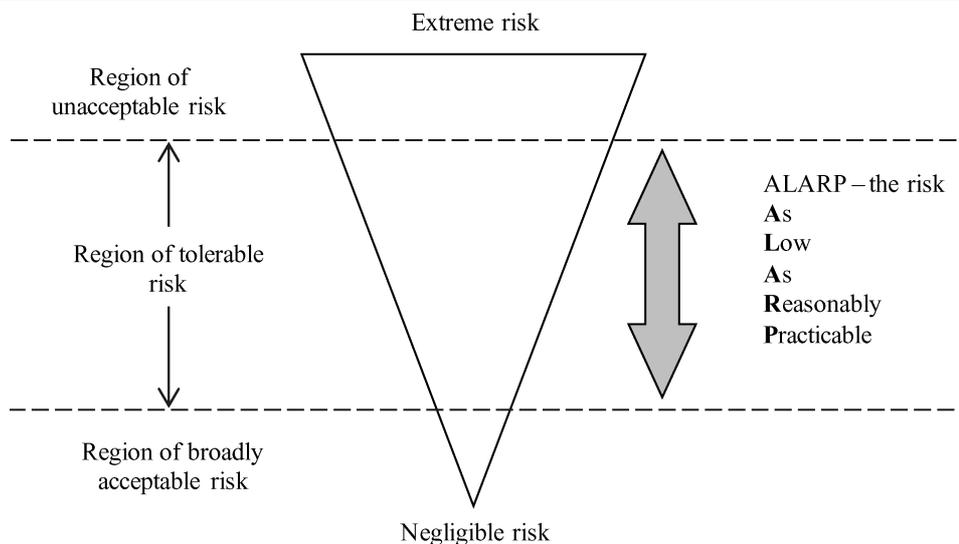


Fig. 8. Dealing with the risk – the ALARP Triangle (based on: [7])

precautions are not practicable or insufficient to protect employees against hazards. PPE often assists to protect workers when they are exposed to the hazard. An employer should ensure that they are appropriate for the job, as well as cleaned, maintained and reviewed regularly. Protective clothing, safety shoes, glasses, earmuffs, dust masks and gloves are the most common examples of PPE.

All risk control measures must be monitored for their effectiveness, to ensure they have been applied correctly and achieve what was intended.

### 3. Example of the risk assessment

The company manufactures seals (thin steel washers coated with gum) for bearings, which are used in automotive and various other industries. In the manufacturing process there are such workplaces as: gum miller machine, rolling-mill machine, extruding press, vulcanizing machine, tightness testing, heat treating, cleaning and silicone coating and sandblasting machine. To carry out the risk assessment, the hazards have been identified and analyzed. Next, two methods of risk assessment, the 3x3 matrix and risk graph (Fig. 7), have been used in order to compare obtained results and take decisions on safety improvement. The example of risk assessment for the extruding press is presented in Table 2.

Matrix method (according to PN-N-18002) has been used to evaluate risk levels for all identified hazards, except the measurable hazards for which occupational exposure standards have been set and must be respected. Assessing the noise and hazardous substances, risk levels have been evaluated on the basis of guidelines detailed in PN-N-18002. With the use of two different methods the same results of risk levels have been obtained. Therefore, it is arguable that in many cases the simple methods of risk assessment are appropriate and enough to use. They enable to identify critical hazards and take decisions on appropriate control measures.

The four biggest hazards connected with the extruder press are: noise exposure, electrical shock, and burns and falls.

Electricity and fire are the potential to be hazardous with possible fatal outcomes. Slipping and falling is the most common cause of injury in the workplace resulting in dislocated and fractured bones [6]. Work related noise exposure is one of the most typical hazards present in the work environment, and hearing loss is one of the most common occupational diseases. According to the data of Nofer Institute of Occupational Medicine in Łódź, in 2014, 169 cases of occupational hearing loss were reported in Poland (7.2% of the total number of occupational illnesses) [19].

The medium risk level means that the risk is tolerable, but the actions aimed at reducing it to the acceptable level should be taken, if reasonable (ALARP principle). Thus, the particular attention should first of all be focused on these hazards.

It is important that effectiveness of implemented control measures is monitored and reviewed on a regular basis to assure they are adequate and sufficient. For this to be successful, regular workplace inspections, safety audits, review of accident rate and investigations, as well as meetings and consultations with employees need to be carried out. Monitoring is an important step in the risk management process and it is the basis for continuous improvement in the area of health and safety at work (Tab. 3).

### 4. Conclusions

In general, health and safety includes protecting people against hazards at work, controlling the related risks and providing a good working environment. These issues are important for the social, economic and legal reasons.

There are important legal duties placed on employers in the area of health and safety at work, including the risk assessment. Companies need support to comply with health and safety rules. International, European and national bodies and authorities have a significant influence on monitoring and enforcing the health and safety standards. There have been developed international and national standards, such as OHSAS 18001 or PN-N-18001 in Poland, which contain useful and practical guides to help employers to set,

Workplace: Extruding press									
No.	Hazards	Risk graph method					Matrix method (according to PN-N-18002)		
		Severity of consequence	Exposure	Possibility of avoidance	Probability of occurrence	Risk level	Probability <sup>1</sup>	Gravity of consequence <sup>2</sup>	Risk level
1.	Electricity	C3	E1	-	P2	Medium	LP	LG	Medium
2.	Fire	C3	E1	-	P2	Medium	LP	LG	Medium
3.	Moving parts of machinery	C2	E1	A1	P3	Small	LP	MG	Small
4.	Collision with moving vehicles	C2	E1	A1	P2	Small	LP	MG	Small
5.	Slips and falls at the same level	C2	E1	A2	P3	Medium	P	MG	Medium
6.	Musculoskeletal strains	C2	E1	A1	P2	Small	P	LG	Small
7.	Stress (time pressure)	C2	E2	A1	P2	Small	P	LG	Small
8.	Dust and contamination	C2	E1	A1	P2	Small	P	LG	Small
9.	Noise (82,4 dB)	C2	E2	A1	P2	Medium	-	-	Medium <sup>3</sup>
10.	Hazardous substances (methanol, benzene, dichloromethane) in solvents	C3	E1	-	P1	Small	-	-	Small <sup>4</sup>

Explanations:

<sup>1</sup> LP – low probability, P – probable

<sup>2</sup> LG – low gravity of consequences, MG – medium gravity of consequences

<sup>3</sup> In general, permissible noise exposure limit for 8 hours is 85 dB, but recommended is 80 dB. According to Polish legislation the Threshold Limit Value for the noise is 80dB for 8-hour workday, and if the exposure level is over this value, an employer is obligated to provide workers with hear protectors if they wish them [18].

Therefore, on the basis of PN-N-18002 if:

$$80\text{dB} < \text{VN}_{8\text{h}} \leq 85\text{dB}$$

the risk level is evaluated as medium ( $\text{VN}_{8\text{h}}$  – measured noise level for 8-hour exposure).

<sup>4</sup>If a worker in the course of 8-hour working day is exposed, at the same time, to more than one hazardous substance, the total exposure rate is calculated according to the following formula [10]:

$$E_t = \sum_{i=1}^n \frac{VC_i}{MPC_i}$$

where:

$E_t$  – total exposure rate,

$VC_i$  – measured airborne concentration of the  $i$ -th substance [ $\text{mg}/\text{m}^3$ ],

$MPC_i$  – maximum permissible concentration of the  $i$ -th substance [ $\text{mg}/\text{m}^3$ ] (on the basis of Threshold Limit Value or Occupational Exposure Limit).

When  $E_t$  is equal or less than 0.5, the risk level is evaluated as a small [16].

Tab. 2. Risk assessment with the use of two methods – comparison of results

implement and maintain a consistent and recognized system of management of health and safety.

The efficient operation of the OH&S system needs engagement and close cooperation of many people, both in health and safety arrangements and implementation of reasonable precautions. For a successful OH&S management system to be developed and maintained, the strong and visible management commitment is necessary, as well as the active involvement of all employees. Each employer should develop a safety policy, strategy and programs, and promote them at all company's levels by effective communication and training, as well as provide necessary resources, facilities and assistance. Health and safety management systems based on the continuous improvement are essential for developing a strong and consistent health and safety culture. To enhance a positive health and safety culture, relevant standards of health and safety expected by the company, should be set. These standards determine desired competencies and behaviors of employees. Competent workers

need sufficient training to perform tasks and duties assigned to them in proper and safe ways. Health and safety training is a vital component of each health and safety management system. It increases employee awareness and understanding of the hazards and risks associated with their jobs. Awareness and understanding of risk is also increased by engaging employees in risk assessment and monitoring. People are better aware of potential hazards associated with their work and working environment, and they know what control measures and related procedures must be followed. Involvement of employees in actions and processes concerning health and safety, supported by appropriate incentive schemes may truly improve staff motivation to positive behaviors and outcomes.

Occupational health and safety management system, based on ongoing risk assessment process can greatly prevent occupational accidents, work-related diseases and other adverse effects on human health. All safety precautions and initiatives, planned and introduced in advance, before

Hazard	Proposed control measures
Electricity	<ul style="list-style-type: none"> <li>– electrical equipment properly installed and used</li> <li>– proper maintenance of electrical systems and work activities</li> <li>– proper insulation, protection and placing of electrical conductors</li> <li>– earthing of conductors</li> <li>– adequate working space, access and lighting</li> <li>– routine visual inspection of electrical equipment carried out by an operator (with sufficient knowledge)</li> <li>– regular testing and inspection of electrical equipment carried out by competent staff</li> </ul>
Fire	<ul style="list-style-type: none"> <li>– good housekeeping</li> <li>– smoking ban in workplaces</li> <li>– control of flammable materials</li> <li>– training employees on safe storage and use of flammable materials, as well as on emergency actions and evacuation procedures in the event of fire</li> </ul>
Noise	<ul style="list-style-type: none"> <li>– using enclosures around the machines to reduce the noise emitted</li> <li>– ear protection including earplugs and earmuffs (if reduction of noise at source is impracticable)</li> <li>– regular and proper maintenance of machines</li> </ul>
Slips and falls	<ul style="list-style-type: none"> <li>– good housekeeping</li> <li>– regular inspections of work areas by supervisors</li> <li>– keeping work areas clean and tidy (according to the 5S methodology)</li> <li>– placing of warning signs when floor surfaces may be dangerous (e.g. wet or uneven)</li> <li>– wearing of suitable footwear by workers</li> </ul>

Tab. 3. Control measures for hazards with tolerable risk level in the extruder press workplace

things go wrong, are absolutely the right way towards safer and safer working environment. It's obvious, that prevention is much more better than cure. Therefore, healthy and safe working environment is important also from the economic viewpoint. Safe workplaces don't have to be expensive and complicated. In fact, the safe workplaces may often save money due to a reduced number of accidents, diseases and ill-health. It leads to better productivity, lower staff turnover and sickness absence. Resources and money put into improving health and safety are regarded as a long-term investment contributing to the company's prosperity. Pro-active and preventive approach to health and safety is the most effective, both in avoiding work-related accidents and diseases and improving company's performance, as well as building the confidence of employees, business partners and wide society.

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## **OCENA RYZYKA ZAWODOWEGO W ZARZĄDZANIU BEZPIECZEŃSTWEM I HIGIENĄ PRACY NA STANOWISKACH**

### **Słowa kluczowe:**

zagrożenia, ocena ryzyka zawodowego, środki zapobiegawcze, system zarządzania bezpieczeństwem i higieną pracy

### **Streszczenie:**

Zapewnienie pracownikom bezpiecznych i higienicznych warunków pracy jest konieczne w każdym przedsiębiorstwie, niezależnie od wielkości, rodzaju i zakresu prowadzonej działalności. Znaczenie odpowiedzialności pracodawcy za zdrowie i życie pracowników wynika ze względów społecznych, ekonomicznych oraz wymagań prawnych. W celu zapobiegania wypadkom przy pracy, chorobom zawodowym oraz innym niekorzystnym następstwom istniejących zagrożeń w środowisku pracy należy systematycznie przeprowadzać ocenę ryzyka zawodowego na stanowiskach. Identyfikacja zagrożeń i ocena ryzyka zawodowego stanowią zasadniczy element systemu zarządzania bezpieczeństwem i higieną pracy. Zagrożenia dla zdrowia i życia pracowników istnieją na każdym stanowisku, a bezpieczeństwo jest możliwe tylko wówczas, jeśli zostaną one rozpoznane oraz podjęte zostaną działania na rzecz ich wyeliminowania bądź zabezpieczenia się przed nimi. Istnieje wiele metod oceny ryzyka zawodowego, które najogólniej można podzielić na ilościowe i jakościowe bądź mieszane. Właściwy dobór metody, a przede wszystkim kompetencje zespołu dokonującego oceny ryzyka, mają duże znaczenie dla poprawy warunków bezpieczeństwa i higieny pracy w przedsiębiorstwie.

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