



THE INFLUENCE OF WORKING CONDITIONS ON EMPLOYEES IN A METALWORKING PLACE OF EMPLOYMENT

Ing. Miriama PIŇOSOVÁ, PhD.

prof. Ing. Ervin LUMNITZER, PhD.

Technical University of Košice, Faculty of Mechanical Engineering, Institute of Design Machine and Process Engineering, Department of Process and Environmental Engineering, Park Komenského 5, 042 00 Košice, Slovak Republic

E-mail: m.p.tuke@gmail.com

Abstract: In the working and outside environment a single factor is never found by itself, rather there are always a number of factors the effects of which can be combined, multiplied and thus adversely affect the human body. Evaluating and assessing health risks at work due to exposure to harmful work factors and the working environment is a challenging and long-term process. Limit values are defined for the categorization of types of work in such a way that it is not foreseeable that, according to current scientific knowledge, they will be detrimental to the health of employees. However, these limit values are set for each factor alone and do not take into account the effect of the combined action of individual factors on the human body. The research aimed at assessing the combined effects of risk factors on human health. The experimental proposal of the assessment focuses on the workplace featuring metalworking machinery and technological equipment. The author paid a significant attention to the risk assessment process and synergistic effects of factors.

Keywords: Metalworking place, employment, environmental quality, risk factors, human health

1. INTRODUCTION

The huge development of science and technology has brought with itself new technologies, new business processes, possibility to explore the unknown, introduce newer and more modern machinery and technologies, automated processes, and also new job opportunities.

With these advances and the introduction of new technologies a new and **yet-unknown risks began to emerge**. The work process now entails more work factors, which are becoming **increasingly difficult to identify, objectify or assess**.

The qualitative-quantitative assessment requires new modern measuring equipment, best laboratories and competent personnel for its implementation. In order to eliminate or reduce harmful factors of work and work environment to the lowest level possible **it is necessary to adopt** a variety of **technological, technical, organizational and other measures**. Despite the adoption of these measures, the workplaces feature physical, chemical, biological and other factors in excess of permissible limits, and **their effects can adversely affect health of employees**.

In order to prevent potential damage to health, it is important to know all the adverse factors that occur in the workplace, **i.e. identify them, objectify them, ensure their quality-quantitative assessment, draw up reports on risk categorization and take measures to reduce them**.

For the assessment of any harmful agents present in the work environment, it is important to know the adverse effects of each one of the present factors and the ways they enter the body, which parts of the body they can damage, what difficulties they may cause, signs they entail, and many others.

Given the fact that the assessment of the combined effects of risk factors is not strictly outlined by our legislative framework, the analysis relies on literature, expert studies and articles on the assessment of the combined effects of the risk factors in the work environment.

2. METALWORKING WORKSHOP

Metalworking workshops or workplaces are usually focused on a specific, contract-based construction processes that use specific machining technology and technological processes (machines and equipment). Thanks to engineering and technical processes, the metalworking is becoming more and more modern.

Despite the achievements of the modern era some of metalworking workshops still use conventional machining technologies (especially in the production of custom-made products), for example chip machining using center lathes, milling machines, drilling machines and carousels. In their work, employees use hand and power tools, which require enhanced safety at work measures.

Metalworking is a process during which a semi-product is shaped into a required shape and dimensions by machining or by changing its shape (eg. bending).

3. ASSESSING THE WORKING ENVIRONMENT USING COEFFICIENTS

Sizing of the analysed factors is assessed using a difficulty factor Q_{dif} . This factor determines **how many times a burden factor exceeds the allowed limit**. It is calculated as follows:

$$Q_{dif} = \frac{Z_r}{Z_p}$$

where: Z_r – value of the actual workload factor, Z_p – value of the permissible workload, Z – overall workload factor $Z_{i,j} = 1, 2, \dots, n$.

In the course of the work, many factors as well as the work environment are affecting employees, which have negative effects on the human body. **The sum of all burdensome factors** that affect humans in different ways is referred to **as a total workload Z**.

This workload factor can be assigned to a **specific degree of workload** using the workload coefficient Z_j with regard to other workload factors – ranging from α_1 to α_n – while keeping in mind that the sum of the values $\alpha_1, \alpha_2, \dots, \alpha_n$ must be equal to one.

If the value of α is **close to zero**, then Z_j has an **insignificant impact** on other factors. If the value of α is **closer to one**, it can be stated that **Z_j has a strong influence** on other factors.

This factor has a decisive effect on the final calculation of the load of the work environment.

Table 1. Assessment of the impact of workplace risk factors on health

Impact on health	Body burden and health and safety	Productivity	Status	Coefficients
WITHOUT AN IMPACT	-	-	optimal	0
INSIGNIFICANT – without permanent sequelae	the possibility of increased workload	occasional drop in work performance	good	0,2
LOW – low impacting sequelae	noticeable body burden	drop in work performance	satisfactory	0,4
MEDIUM – serious sequelae	possible risks	significant drop in work performance	acceptable	0,6
HIGH – life-long sequelae	very high risk	low work productivity	unfavorable	0,8
EXTREMELY HIGH – death	the possibility of fatal accidents	working is almost impossible	unacceptable	1

The value of the total instantaneous workload

$$a_c = \sum_{j=1}^n \alpha_j \cdot \frac{z_j^r}{z_j^p}$$

$$\alpha_j \cdot \frac{z_j^r}{z_j^p}$$

reflects the actual body burden of the workload factor Z_j from the all resulting load factors Z_1, Z_2, \dots, Z_n

To obtain specific data it is necessary to take into account **health statistics** (occupational diseases, the likelihood of the occurrence of occupational diseases), **the effect of risk factors on the accident rate in a particular operation, hygienic conditions of operation, health and safety measures and productivity.**

4. EXPERIMENTAL PROPOSAL

The health risk assessment process is essential for the safety and health of workers at work. Negative impacts on employees are greater when there are several negative influences present at the workplace.

The methods and procedures used in the assessment of the work environment **are intended to quantify the extent of damage inflicted to human health.** Therefore, it is necessary to properly select an appropriate method for a comprehensive assessment of the quality of the working environment. Using this method, it would be possible to determine the level of workload at the workplace.

A. Synergistic effect

The current status of the work factors and factors of working environment is assessed by assessing one factor at a time. Following the qualitative-quantitative assessment, it is necessary to assess these factors in a comprehensive way.

Thus, **if one factor affects** the human body in a **negative** way and can harm the human organism, **the coexistence of such factors may increase the negative impacts** by their synergistic effects (mutual active interaction) or by potentiating the factors, which means the factors are complementary to each other.

However, **the opposing effects** of work factors and factors of working environment are also well-known. When assessing effects of work factors and factors of working environment it is important to consider each factor and its effect on the human organism individually. However, if we want to quantify their overall effect on employees, it is essential to assess effects of work factors and factors of working environment comprehensively and never underestimate their negative effects on the human body, especially if the values of factors are below the limit, since their synergistic effect can significantly damage employees' health. Therefore, it is important to find a solution to the issues related to synergy.

It is necessary to highlight the fact that every phenomenon has its own specificities, and it is important to carefully examine and evaluate them gradually. The synergistic effect outlines the intensive and prolonged effect of factors which together create one final effect.

At the beginning, a number of negative effects may for some time seem **insignificant.** Likewise, positive effects may seem **unjust or inefficient.**

Even in terms of fictitious metalworking workshop, a synergistic effect of noise which exceeds upper exposure action values, vibrations transmitted to the whole body or hands not exceeding action values of the normalized vibration acceleration and microclimate conditions such as cold, dampness and physical stress can after a long-term exposure have an adverse impact on health or even cause an occupational disease.

B. Time frame proposal

For a more thorough analysis of the impact of risk factors it is necessary to develop a detailed time frame which will be used in initial measurements.

For the better assessment of synergy effects on employees the time frame includes periods of exposure to vibrations and noise for various activities carried out during the eight-hour working time.

In order to assess the combined effects of work factors and working environment factors we need information about **objectification, qualitative - quantitative assessment, information on employees' job positions** and other related documents regarding **data on the workplace, the subject matter, and various other documents.**

In order to obtain more relevant data needed for the assessment we have **proposed and designed a comprehensive questionnaire**. Its primary aim is to get information directly from employees working at a particular workplace. The questionnaire has not yet been filled out and only serves as a proposal for the assessment of combined effects. Due to the limited scope of this article we will not describe it any further.

C. Final evaluation and a flowchart

In order to eliminate occupational diseases at the workplace it is important to identify risk factors and monitor the incidence of health problems among employees. The professional assessment of the work environment, working conditions and the way of working it is necessary to consider each of the factors individually, but at the same time sensitively, responsibly and professionally in accordance with the qualitative-quantitative assessment and the current scientific knowledge. Moreover, it is also important to evaluate and assess comprehensively all the negative synergistic effects in order to eliminate or at least reduce their harmful side effects on the body.

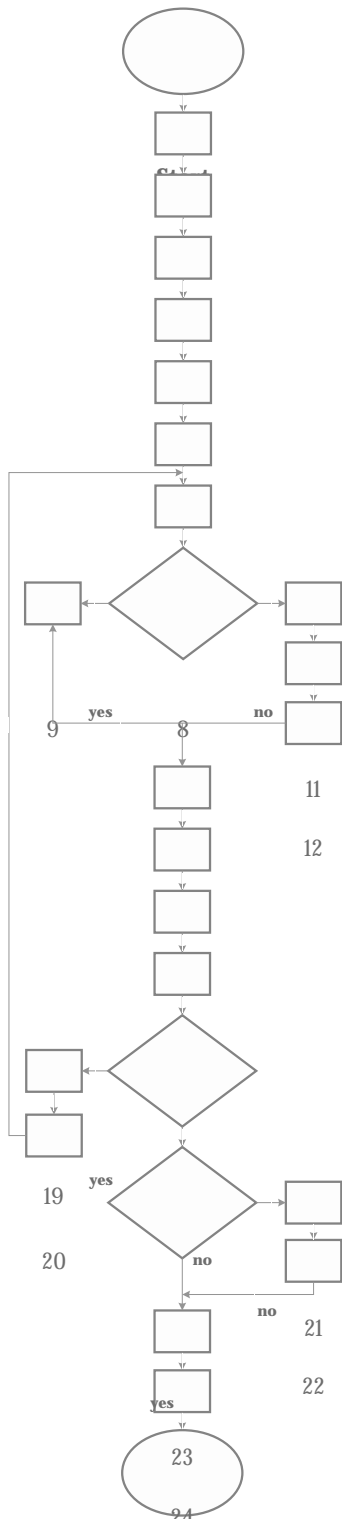


Figure 1. Evaluation of health risks – flowchart
Description of the flow chart:

1. The identification of hazardous risk factors at the workplace.
2. Sanitary survey at the workplace survey. Definition and determination of factors.
3. Definition of the time frame needed for the assessment and measurements.
4. Preparation of documentation and equipment for the measurement and assessment.
5. Measurement of noise, vibration and climatic conditions.
6. Assessment of physical activities.
7. Preparation of records, methodology descriptions, outputs from the measuring devices.
8. Are measurements carried out in line with the time frames for all job positions?
A – The measurements are carried out in line with time frames

N – Not all measurements have been carried out.

9. Processing of measurement results and the base documents for the assessment of physical load.
10. Adding professions and drafting / editing TF.
11. Carrying out additional measurements of physical factors.
12. Completing measurement results and base documents for the assessment.
13. Evaluation and assessment of the health risks.
14. Developing the risk assessment including the Risk Management Plan.
15. Submitting a proposal to the relevant Regional Public Health Authority for inclusion of the specific works into the third or fourth category of work/ submitting a proposal for changing or removing the works from the third or fourth category.
16. Implementation of measures of the Risk Management Plan, review the health risks, preparation of documents.
17. Have changes been implemented?
A – Changes that have an impact on the inclusion / removal into / from the third and fourth category have been made.
N – No changes that would have an impact on the inclusion / removal into / from the third and fourth category have been made.
18. Checking the up-to-date nature of the risk assessment, checking the compliance with the Risk Management Plan, updating records:
A – Reviews are valid; Risk Management Plan is being met.
N – Changes to the risk assessment.
19. Updating TF, completing documents on the changes taking place at the workplace.
20. Implementation of complementary (questionnaire) surveys and measurements of harmful factors.
21. Reviewing changes in working conditions, data update.
22. Additions and changes in risk assessment.
23. Informing the management.
24. Archiving documents.

The assessment of synergistic effect of work factors and working environment factors is not strictly governed by any legislation that would lay down assessment procedures or outline rates, levels and conditions of the harmful effects on employees. We suggest the following assessment procedure:

- Risk assessment, categorization, the decision on hazardous work. Time exposure and job descriptions. Reports on the measurement and assessment of harmful factors.
- Risk analysis carried out on the basis of a questionnaire.
- Detailed analysis of reported occupational diseases and threats of occupational disease.
- Analysis of health status of employees made on the basis of information contained in a medical opinion on work capability.

The first point of the assessment

For the purposes of the assessment we propose the following markings and score:

Table 2. Data for the risk categorization

Noise	Vibration	Physical Exercise
category 2 N2 - 4	category 2 V2 - 4	category 2 PE2 – 4
category 3 N3 - 6	category 3 V3 - 6	category 3 PE3 – 6
category 4 N4 - 8	category 4 V4 - 8	category 4 PE4 - 8

Points-based assessments 4, 6 and 8 were designed for the appropriate category of health risk based it is the level of seriousness.

The second point of the assessment

When analyzing the data received from the questionnaire, we can obtain other important data as well. Such data is likely to be objective and fairly accurate since it is given by employees voluntarily and mostly on an anonymous basis.

The questionnaire provides very important data on the age range of respondents and information on their exposure to risk factors. Such data is important in determining the level of risk - whether it is a

medium, high or very high risk with regard to the age of an employee or the probability of health damage given the length of exposure to risk factors - **low, medium, high and very high**.

Table 3. Probability of harm to health in relation to the age of the employees

The word sign of probability	Value	In short
Extremely High	6	A-EH
High	4	A-H
Medium	2	A-M
Without an Impact	0	A-WaI

The third point of the assessment

A detailed analysis of reported occupational diseases and threats of occupational disease at the workplace provide important data for the assessment of synergistic effects of the monitored harmful factors.

By analyzing the reported occupational diseases, we can obtain detailed information about minimum, maximum and average age of employees at the time of the occurrence of the occupational disease, as well as information about minimum, maximum and average exposure time prior to the occurrence of the occupational disease.

The fourth point of the assessment

The first medical restrictions stated in a medical opinion on work capability fitness or medical work restrictions supported by medical check-ups will give us information on the time of exposure to harmful factors which have not caused any harm yet, and the early signs of damage to health. From such data we can then calculate the minimum length of carrying out work in the work environment without inducing any harm or indicate time when such effect will start to appear. These conclusions can be the basis for a timely redeployment in order to prevent the impact of harmful factors.

To determine the values to indicate the potential risk of harm to health from occupational disease, the risk of occupational disease, health limitations from medical assessments it is possible to determine the scale of risk severity using points-based evaluation as follows:

Table 4. The scale of the occupational diseases risk

The number of reports occupational diseases at the workplace	The word sign of risk	Value	In short
≥ 3	Extremely High	10	O-EH
≤ 2	Medium	5	O-M
0	Without an Impact	0	O-WaI

In a similar manner were also proposed additional scales (the scale of the occupational disease risk, the scale for the restrictions resulting from medical reports, the likelihood of damage to health – a synergistic effect).

A summary table assessing the combined effects of work factors and working environment factors serves as a basis for the resulting summary documents which were obtained from four basic sources, namely the risk assessment and work categorization, the analysis of data provided in the questionnaire, the detailed analysis of occupational diseases and threats of occupational diseases, the analysis of data contained in a medical opinion on work capability during regular medical check-ups of employees.

Table 5. Resulting table of evaluation of synergistic effects of factors

Profession	Categorization of works			Occupational diseases	Endangered by occupational disease	Health restriction	Age risk	Exposure time	Synergistic effect
	N4	V3	PE4						
Lathe operator	N4	V3	PE4	O-M	T-EH	R-EH	A-H	E-EH	S-EH
	8	6	8	5	6	4	4	8	8
Tool sharpener	N4	V4	PE3	O-WaI	T-EH	R-EH	A-H	E-EH	S-EH
	8	8	6	0	6	4	4	8	8
Milling machine operator	N2	V2	-	O-WaI	T-WaI	R-M	A-H	E-H	S-L
	4	4	-	0	0	2	4	6	2
Metal worker	N3	V2	PE4	O-WaI	T-M	R-EH	A-EH	E-EH	S-H
	6	4	8	0	4	4	6	8	6
Horizontal driller	N3	V2	-	O-WaI	T-WaI	R-M	A-H	E-EH	S-L
	6	4	-	0	0	2	4	8	2
Crane operator	N2	V3	-	O-M	T-M	R-EH	A-M	E-H	S-H
	4	6	-	5	4	4	2	6	6
Warehouse worker	N2	-		O-WaI	T-WaI	R-M	A-H	E-H	S-L
	4	-	4	0	0	2	4	6	2

The assessment of the combined effects of working as a profession fitter / lathe operator has given the related synergistic effects the score 8, i.e. very high probability of potential damage to health due to several factors related to the work environment and tasks performed. The employee performing the above-mentioned tasks was placed in the following categories: fourth category due to the noise factor, the third category for vibrations factor and fourth category due to physical load.

From the documents provided it be found that at least one occupational disease and more than three threats of occupational diseases were reported at the monitored workplace. In addition, medical check-ups revealed more than three health restrictions. According to data provided, the age of the employee in question ranged between 45-49 years, which was assessed as a high risk. The given employee had been exposed to the risk factors for more than 20 years, which was assessed as very high probability of a potential harm to the body.

On the basis of data obtained the profession of fitter/ lathe operator was assessed as a profession with a very high probability of harm to the body (if the work conditions will not change).

5. CONCLUSION

Proposing a method for assessing the combined effects of the risk factors in the chosen work environment and its implementation into practice is a long process. Since the risk assessment is not clearly defined in the legislation, the actual assessment of the combined effects of risks requires an experienced team of experts working in the field of qualitative-quantitative assessment and health risk assessment and a lot of work. Moreover, it is necessary to obtain the maximum possible number of data on the employment in a given workplace.

For the overall assessment, it is also very important to know the incidence of harm health from work in a given workplace and to conduct a detailed analysis of occupational diseases, risk of occupational disease or health limitations resulting from the conclusions of the medical examinations carried out. A detailed analysis also requires the age of exposed employees and the length of exposure of employees to individual factors of work and the working

environment. The proposed staff questionnaire provides the quantity of data needed for an overall assessment of the combined effects of risk factors.

Summarizing all the proposed source data, its subsequent analysis and comprehensive assessment and evaluation is beneficial to the understanding of the impact of the synergistic effects of risk factors on employees in the working process at any workplace, in carrying out various work activities, especially those that are included in the category of health risks. The high professional and practical experience of the members of the evaluating team is another successful basis for using all source data and maximizing the benefits of evaluating the combined effects of risk factors in the work environment.

The difficulty and diversity of the work process and the occurrence of a large number of harmful factors of work and the working environment, including those that did not exist in the past or those that occur in workplaces due to the tremendous development and progress in all manufacturing areas requires assessment of factors of work and the working environment not only separately for individual risk factors but it is necessary to arrange the continuous comprehensive assessment of the combined effects of these factors on the human body as a basic requirement to protect the health of employees in carrying out work activities and to prevent harm to health caused by work.

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