Identification of safety indicators in the manufacturing industry in Republic of North Macedonia and their impact on the occupational injury lost time

Trajce Velkovski[1][0000-0003-0502-0556], Jasmina Chaloska[1][0000-0002-0577-7703], Vladimir Mučenski [2][0000-0001-9830-4747], Bojan Jovanoski [1][0000-0002-4010-4504] and Bojan Jovanovski [3][0000-0003-4340-8092]

[1] University Ss Cyril and Methodius, Faculty of Mechanical Engineering, Skopje, Republic of North Macedonia
[2] University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Republic of Serbia
[3] FH JOANNEUM University of Applied Sciences, Graz, Austria
trajce.velkovski@mf.edu.mk

Abstract. The Constitution of the Republic of North Macedonia, in particular Article 32, paragraph 1, clearly states that "Everyone has the right to work, free choice of employment, safety at work and material security during temporary unemployment". The focus in the research is to contribute for reducing the lost working time in the companies in the manufacturing industry, as a result of occupational injuries and to increase the employee productivity and competitive advantage through development of safe working environment. The identification of the safety indicators is based on the analysis of existing scientific and research literary sources, OSH legislation in Republic of North Macedonia and Delphi method. The final result of the research is a developed methodology with structure of 50 identified safety indicators, divided into 14 groups. Each indicator is defined by a weight factor rated by the Delphi expert group based on its impact on reducing the time lost by the occupational injuries. The safety indicators are identified by reaching consensus of 32 occupational safety experts in two Delphi iterations.

Keywords: safety indicators, occupational health and safety, occupational injuries, manufacturing industry, Delphi method

1 Introduction

The World Health Organization (2018) statistical data [1], shows that a total of 7.500 workers die every day, of which 1.500 from occupational injuries and 6.000 from occupational diseases. Such statistical indicators worldwide, which present an increasing number of occupational injuries and diseases, indicate urgent need of preventive measures in the area of OHS worldwide, such as identification of safety indicators. A safe and healthy work environment directly affects and increases the motivation and

confidence among employees and reduces the occupational stress by lowering the expectation that some kind of occupational injury will occur.

The Law on Occupational Safety and Health of the Republic of Northern Macedonia as well as the Directive 89/391 / EEC [2] obliges all legal entities to conduct a risk assessment at each workplace, which regulates the obligations of employers, the rights and obligations of employees, occupational safety experts and OSH employee representatives. The analyses of occupational injuries in the manufacturing industry in Republic of North Macedonia (RNM) are presented only for the period from 2009 to 2012 [3] (figure 1), in absence of official statistical data regarding OSH [4]. The highest number of occupational injuries in RNM occurred in the construction industry, followed by manufacturing, health, traffic and other industries. However, the focus of occupational safety research on the construction industry, does not mean that other industries should be neglected, especially the manufacturing industry [5]. The situation in the manufacturing industry, in terms of occupational injuries, unfortunately is similar to the construction industry [6], having very high trendline that shows 2.8 times more occupational injuries in 2012 than in 2009. This positive trendline in the number of occupational injuries is due to the fact that the manufacturing industry is the largest employer in RNM, and thus statistically significant number of occupational injuries belongs to this industry. According the data in figure 1 there is a significant increase in the number of occupational injuries noted in 2012, which is an evident in the construction and manufacturing industry. Those data suggest that the workplaces in the construction and manufacturing industries are the most dangerous working places with the highest risk and possibility of occupational injury.

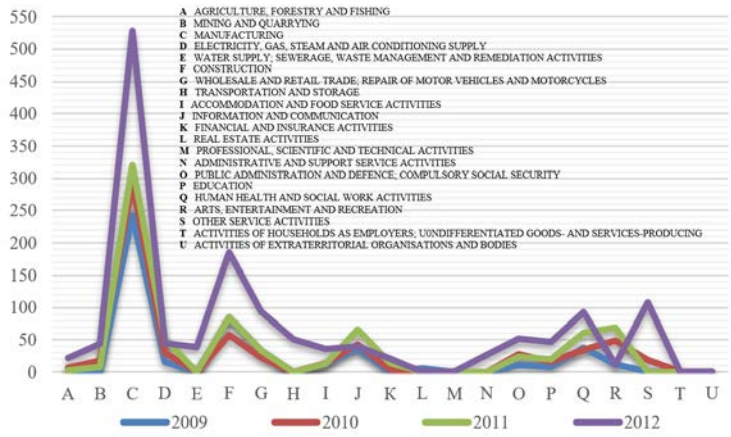

Figure 1. Total number of injuries in the RNM in the period from 2009 to 2012 according to the National Classification of Activities, harmonized with the international NACE Rev. 2

If we analyse the cumulative number of injuries in the period of 3 years (2009 to 2012), then the results show that in the manufacturing industry there are total of 1386, and in construction 414 occupational injuries. These two industries together represent 54% of the total number of reported occupational injuries in the RNM for that period.

2 Literature review

Through the research literature dozens of survey questionnaires have been developed in order to identify the key safety indicators [7, 8, 9]. Among the first, and definitely one of the most influential questionnaires, was developed in 1980 by the Israeli researcher Zohar [10] where in his research he determines eight safety indicators.
Coyle and his research team [11], also confirm in their extensive research, that there is no universal set of safety indicators that can be implemented in all industries at all working places.
The research conducted to determine the safety indicators that contribute to increasing performance in the manufacturing industry [12] and includes 30 occupational safety experts. These experts answer a 140-item questionnaire by conducting an assessment according to a five-point Likert scale. Safety indicators with the highest impact from the research are: management commitment, established OSH system, involvement of employees and their attitude towards OSH and the working environment, i.e. the climate for safety. The indicator of management commitment is one of the most important through the literature review, which in almost all researches where there is some hierarchy between indicators, is in the first place. In 88% of the analysed literature, it is presented and singled out as one of the most influential safety indicators for increasing the level of occupational safety and reducing the number of occupational injuries lost time. In some of the analysed literature [13, 14], the safety indicator for top management commitment is pointed out as the main indicator for increasing performance in the implemented occupational safety and health system.

3 Methodology

The methodology applied for collecting, systematizing and analysing the necessary data is a sublimate of applied qualitative and quantitative scientific research methods. In order to respond to the set of scientific research challenges, it is first necessary to make an analysis of the current situation and scientific research, as well as the legislation in RNM [15]. Through the application of qualitative research methods, analysis and synthesis group of safety indicators that are reducing the number of occupational accidents and increase the safety at work has been identified. The analysed safety indicators are further synthesized in order to prepare a list of safety indicators which is subject to additional research through a group of experts in the Delphi method. In the implementation of the Delphi method, a combination of different statistical methods is used, which contribute to the quantification of the questionnaire and setting of the weighting factors for each of the safety indicators based on their impact on the occupational injury lost time.
In the first step of Delphi method the selection of the expert group was based on special criteria developed by literary review from the results of related scientific research and recommendations. Those criteria comply the introductory questionnaire with a total of eight criteria, two of which are mandatory and six optional criteria. From the eight

criteria defined, experts must meet two mandatory criteria and an additional three of the remaining six non-mandatory criteria, in order to be included in the expert group. The introductory questionnaire was posted on an internet platform and sent to 86 occupational safety experts and answered by 65%, i.e. 56 respondents. From the answers received from 56 respondents, only 41, i.e. 73%, meet the required criteria. Those experts composed a group of highly qualified experts in the field of occupational safety in the manufacturing industry. They analyse the safety indicators through two iterations and evaluates them by assigning an appropriate weight factor according to their impact on the occupational injury lost time. At this stage of the research, each expert has the opportunity to add or subtract a certain indicator, of course if a consensus is reached by all experts on such a decision. After each Delphi iteration, an analysis of the results is performed to check the consensus reached between the expert group, which out of 41 qualified experts, received answers in from 32 experts in all iterations. Expert consensus was reached in the second Delphi iteration, which is verified by the low level of the statistical indicators, coefficient of variation and coefficient of quarterly deviation

3.1 Identification of safety indicators in the manufacturing industry

With the identification of the safety indicators in the manufacturing industry the model has been created as shown on figure 2.

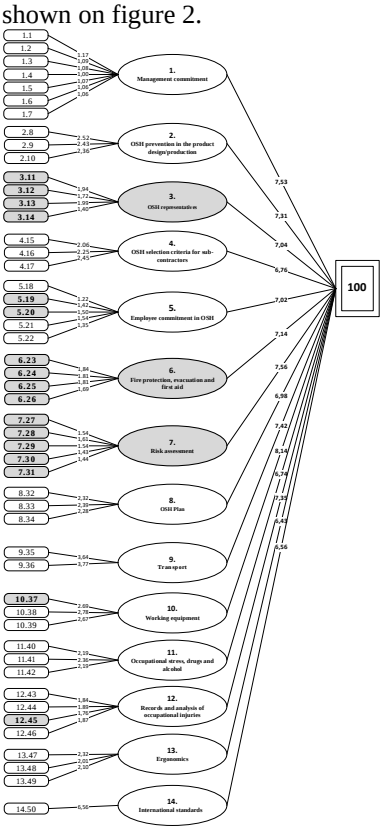

Figure 2. Model of safety indicators in the manufacturing industry

According the scores obtained from the two iterations in the Delphi method, the sum of the mean values of the weighting factors provides a grading system with a total sum of 203.25 weight factor (WF). This large number of the total weight factor is due to the fact that the ratings of the experts in the Delphi method are given on the basis of a five-point Likert scale, from 0 to 5. For easier interpretation of the model results and its more efficient application in practice, the system for rating is normalized for its total value to be 100 credits (figure 2).

Based on the literary review of the existing scientific researches and the National legislation in the field of occupational safety and health in RNM, as well as the application of the Delphi method trough expert's assessment, a table with a list of safety indicators in the manufacturing industry has been created (table1).

Table 1. Safety indicators in the manufacturing industry

ID	SAFETY INDICATOR	WF
1	**Management commitment**	**7,53**
1.1.	OSH commitment of the manager/owner of the company	1,17
1.2.	OSH commitment of the manager of production/technical manager	1,09
1.3.	OSH commitment of the administrative chief	1,08
1.4.	Additional/specialized OSH training for management	1,00
1.5.	OSH meetings with employees	1,07
1.6.	OSH meetings with top management	1,06
1.7.	Meetings with employees when introducing new products, materials, technologies, tools and machinery	1,06
2	**OSH prevention in the product design/production**	**7,31**
2.8.	Designing/constructing/developing technology safe for workers	2,52
2.9.	Identification of hazards in the phase of construction/product design/technology design	2,43
2.10.	OSH training for designers/constructors/production engineers	2,36
3	**OSH representatives**	**7,04**
3.11.	Occupational safety expert	1,94
3.12.	Employees occupational safety representative	1,72
3.13.	Occupational safety expert is familiar with all hazards	1,99
3.14.	Trade union representative is committed in the implementation of the OHS system	1,40
4	**OSH selection criteria for sub-contractors**	**6,76**
4.15.	OSH selection criteria for sub-contractors	2,06
4.16.	Responsible person for sub-contractor's control	2,25
4.17.	Agreement with sub-contractors regarding the OSH standards	2,45
5	**Employee commitment in OSH**	**7,03**
5.18.	During the process of selection of new employee, knowledge in OSH is evaluated	1,22
5.19.	Employees have performed health examination	1,42
5.20.	Employees attended training in OSH	1,50

5.21.	There is an employee in every shift, authorized to stop the production process if potential hazard is identified	1,54
5.22.	Measurement of the performance in OSH is part of the performance measurement system for managers/employees	1,35
6	**Fire protection, evacuation and first aid**	**7,14**
6.23.	All safety measures against fire are adopted	1,84
6.24.	Safety measures for first aid in case of emergency are adopted	1,81
6.25.	Safety measures for evacuation in case of emergency	1,81
6.26.	Agreement with a health institution in the field of occupational medicine, with legal entity specialized to provide first aid services, emergency medical assistance for activities in evacuation and rescue and fire protection	1,69
7	**Risk assessment**	**7,56**
7.27.	Risk assessment and hazard analysis from authorized legal entity for performing occupational safety services	1,54
7.28.	Work environment assessment	1,61
7.29.	Hazardous substance management plan	1,54
7.30.	All OSH measures have been taken for employees under 18 years old and over 57/59, pregnant women, employee with a sick child and a single father parent	1,43
7.31.	Warnings and signs for potential hazards are properly set at the workplaces and at the working equipment (according the act for OSH signs)	1,44
8	**OSH Plan**	**6,98**
8.32.	The production plan (capacities, normative, timeline) harmonized with the OSH system (based on the principle to reduce the risk)	2,32
8.33.	Program for planning measures and means for providing development and improvement of OSH system	2,39
8.34.	Plan for maintaining clean working environment (with activities and responsibilities)	2,28
9	**Transport**	**7,42**
9.35.	Measures for safe external transport (outside of the company) speed limit, and GPS tracking of the means of transport	3,64
9.36.	Measures for safe internal transport, machines and vehicles	3,77
10	**Working equipment**	**8,14**
10.37.	Working equipment (machines and tools) are safe for the operators	2,69
10.38.	Machine operators have the appropriate qualifications	2,78
10.39.	There is a procedure for maintenance of the working equipment	2,67
11	**Occupational stress, drugs and alcohol**	**6,74**
11.40.	Occupational stress reduction program, action plan for stress prevention (discrimination, violence, bulling, mobbing, burning syndrome)	2,19
11.41.	Alcohol testing program	2,36
11.42.	Drug and drug substances testing program	2,19
12	**Records and analysis of occupational injuries**	**7,35**
12.43.	Keeping records of every incident and "near miss"	1,84

12.44.	Analysis and research of every incident and "near miss"	1,89
12.45.	Keeping records (legal obligations according to the legal act)	1,76
12.46.	Effective internal OSH inspections	1,87
13	**Ergonomics**	**6,43**
13.47.	Ergonomic analysis of working activities and their appropriate adaptation	2,32
13.48.	Employees ergonomic exercises program	2,01
13.49.	Ergonomic principles for reducing monotone and repetitive movements	2,10
14	**International standards**	**6,56**
14.50.	Implementation of International standards	6,56

This list of safety indicators (table 1) contains 50 indicators distributed in 14 main groups. Out of the total number of 50 safety indicators that have been identified, 34%, i.e. 17 indicators arise as a result of the legal obligations for OSH (marked in bold and grey on figure 2.).

4 Conclusion

Safety indicators which affect the reduction of occupational injury lost time, have been identified according to the developed research methodology, through the analysis of existing data from various sources. Those safety indicators are identified through: the analysis of the existing literature, with the results from the scientific papers in the field of OSH, the legal obligations in accordance with the national legislation on OSH in the RNM and the implementation of Delphi method. The result of the research is a list of identified 50 safety indicators, distributed in 14 groups.

In the results of the Delphi method, the largest weight factor assessed by Delphi experts is the group of indicators related to the working equipment. Such results are expected, given that the research addresses the manufacturing industry where machinery and tools are one of the leading causes of occupational injuries. The next two groups according to the weight factor obtained by the experts in the Delphi method are: risk assessment and management commitment. Risk assessment is a legal obligation, in accordance with national OSH legislation and is the basis of all OSH systems for hazard identification, which contributes to specific risk mitigation measures. The management commitment, as a group of indicators in this research is assessed with a high weight factor, that confirms the literature review analysis with the same results showing highest impact on this safety indicator.

From the research results and analysis, data are obtained on the critical points of certain OSH systems, which is the basis for corrective measures and upgrading of the system. This opportunity for self-evaluation and comparison of OSH systems in relation to other legal entities in the processing industry, enables the sustainable development of OSH systems.

References

1. World Health Organization. Regional Office for Europe." European health for all database (HFA-DB).". Retrieved 20/01/2019, from http://data. euro. who. int. (2019)
2. EU. (1989). Council Directive 89/391/EEC of 12 June on the introduction of measures to encourage improvements in the safety and health of workers at work. Official Journal of the European Communities, 183, 1-8. (1989)
3. Ministry of Labor and Social Policy in Republic of North Macedonia, State Labor Inspectorate: Annual Reports (2009, 2010, 2011, 2012)
4. Velkovski T., Chaloska J. and Dudeski Lj.: Analysis of the monitoring system of occupational injuries in Republic Macedonia. Proceedings, International conference for regional collaboration, OSH BON TON, Ohrid, R. Macedonia. (2015)
5. Chaloska, J., Dudeski, L., & Velkovski, T..: Overview of the Macedonian situation in the field of occupational safety and health and future recommendations. Annals of the Faculty of Engineering Hunedoara, 13(3), 227. (2015)
6. Mucenski, V., Trivunić, M., & Peško, I.: Risk analysis for occupational injuries caused by machinery usage in building process. Mechanical engineering scientific journal, Vol. 33, No.3, pp. 281–286. Faculty of Mechanical Engineering Skopje, Republic of Macedonia (2015)
7. Flin, R., Mearns, K., O'Connor, P., & Bryden, R.: Measuring safety climate: identifying the common features. Safety science, 34(1-3), 177-192. (2000)
8. Glendon, A. I., & Litherland, D. K.: Safety climate factors, group differences and safety behaviour in road construction. Safety science, 39(3), 157-188. (2001)
9. Guldenmund, F. W. : The nature of safety culture: a review of theory and research. Safety science, 34(1-3), 215-257. (2000)
10. Zohar, D.: Safety climate in industrial organizations: theoretical and applied implications. Journal of applied psychology, 65(1), 96. (1980)
11. Coyle, E. F.: Integration of the physiological factors determining endurance performance ability. Exercise and sport sciences reviews, 23(1), 25-64. (1995)
12. Hamid, S. A., Goolamally, N., & Leman, A. M.: Determinants of factors contributing to OSH performance in manufacturing industries: A pilot study. In AIP Conference Proceedings (Vol. 2030, No. 1, p. 020091). AIP Publishing LLC. (2018)
13. Cohen, A.: Factors in successful occupational safety programs. Journal of safety research, 9(4), pp.168-178. (1977)
14. Al-Refaie, A.: Factors affect companies' safety performance in Jordan using structural equation modeling. Safety science, 57, 169-178. (2013)
15. Low on occupational health and safety ("Official Gazette of the Republic of Macedonia" No. 92/2007, 136/2011… 60/2012)
16. Minovski, R., Jovanoski, B., & Galevski, P.: Lean implementation and implications: experiences from Macedonia. International Journal of Lean Six Sigma. (2018)
17. Velkovski T., Chaloska J., Petkovski M., Jankova S.: National study for Occupational safety and health, Republic of Macedonia, Macedonian association for protection at work, Skopje. (2018)