ABOUT SOME WAYS TO OPTIMIZE ENVIRONMENTAL CONDITIONS AT WORKPLACES SPECIFIC MANUFACTURING OF ELECTRONIC AND ELECTROTECHNICAL PRODUCTS

Ramona DZITAC[1], Gabriela-Victoria MNERIE [2], Titus SLAVICI[3]Dumitru MNERIE [4], Viorica BAESU[5], Bogdan COTLEȚ[6]

Abstract: At a workplace, environmental conditions represent an important risk factor. Risk management in companies that have workplaces as part of the technological flows for manufacturing electrical and electronic products currently faces problems, due to the particularities of the working environment for operators. Optimizing environmental conditions at these workplaces is a major current goal. In the context of societal progress, workers are demanding much more demanding requirements for work requirements. Thus, multidisciplinary research is required to aim at greater compliance with the requirements of employees to have a workplace that is as clean, refined, and aesthetic as possible, in accordance with modern ecological culture, according to high standards. Due to this aspect, but also to the increase in cases of occupational diseases due to this category of employees, this research seeks to contribute to the search for ways to achieve unitary systems, integrated into the production system, which would permanently monitor the conditions for each workstation, with immediate notification of exceeding the limits within which the characteristic environmental parameters must fall, so as not to affect the health of the workers. Experimental research was carried out based on several types of measurements, in different working positions. The results obtained were interpreted, noting different extreme values, over short periods of time, which are not immediately detected. These shortcomings of the classical methods of monitoring environmental conditions and the presence of occupational hazards. Several essential measures are proposed to improve the monitoring of environmental conditions, so that these workplaces are safer and healthier for operators. There are also references to improving risk management, but also to increasing the level of employee training.

Key words: risk factors, work environment, monitoring, special manufacturing, health, optimization, workplaces.

1. INTRODUCTION

Contemporary society uses a wide range of electronic devices that are built in factories operated by industry, which are almost always partially automated. The rhetorical question is: why is automation not found to a sufficient extent in workplace risk management? [1]

Currently, the *Electrotechnical and Electronic Engineering* (EEI) industries are expanding more and more. They include the manufacture of a diverse range of electrical and electronic components and devices, wiring, radio and telecommunications equipment, etc. It represents a sector of the economy, comprising a set of enterprises concerned with the design, manufacture and marketing of machines, devices and consumables for the generation, storage and use of electrical energy. With the expansion of EEI-specific jobs, the risk factors that can affect the health of workers have diversified [2].

Optimizing the environmental conditions at the workplace specific to the manufacturing of electronic and electrotechnical products is a major current goal, given that risk management while maintaining strict quality standards is a challenge faced by almost every industry [3].

In the contemporary business environment, a much more pronounced attitude is currently observed towards the simultaneous inclusion of three essential states: health, well-being and productivity. These are directly related to the key factor given by the environment in which we live

[1]PhD student, *POLITEHNICA University Timisoara*, *Inspector Labor Inspectorate of Timis County*, Romania, dzitac.ramona@yahoo.com
[2]Researcher, PhD, *R&D National Institute for Welding and Material Testing, 30, Mihai Viteazu Blv., 300222 Timisoara, Romania*, dumitru_mnerie@yahoo.com
[3]Prof. Univ. Ph.D. Eng., *Politehnica University, Ioan Slavici University, Timisoara, Romania*, titusslavici@yahoo.com
[4]Prof. Univ. Ph.D. Eng., *Ioan Slavici University, Politehnica University*, Timisoara, Romania, dumitru_mnerie@yahoo.com
[5] Lecturer, PhD in Ec., *Ioan Slavici University, Timisoara*, Romania, viobaesu@yahoo.com
[6] Lecturer, PhD in Ec., *Ioan Slavici University, Timisoara*, Romania, bogdancotlet@yahoo.com

and work. In the specialized literature there is a series of research on risk factors, starting from acoustics and air quality, to lighting and appearance [4].

To find the best ways to optimize the conditions provided at the workplace, it is necessary to better cooperate with those responsible for OSH and those in occupational medicine, to prevent illnesses due to the working environment [5].

To impose effective measures, a rather complicated interaction is noted between ethics, law and social responsibility at the workplace, regarding the health of employees [6].

In terms of legislation, in each country it is sought to improve it, in accordance with the evolution of technology, changes in the industrial environment and the expectations of employees regarding the provided workplace environment. Thus, the new Law on Safety and Health at Work No. 35/23, which is now applicable in Serbia, brings more demanding provisions related to the obligations and responsibilities of the employer, regarding health. protection at the workplace, professional examinations and the issuance of licenses [7].

It is always necessary to carry out research that aims to meet the requirements of employees to have a cleaner, more refined, aesthetic workplace, in accordance with modern ecological culture, with priority given to high standards regarding the quality of life of each person [8].

On these coordinates, this paper seeks to bring real contributions to the practice of monitoring environmental conditions specific to the work environment in which employees in the electrical and electronics industry carry out their activity, based on case studies carried out in profile companies in Timiș County (Romania).

2. METHOD AND PROCEDURE

In general, the analysis of risk factors in a workplace is carried out by considering 4 categories of risk factors, which are classified according to the origin of the causes. Thus, risk factors can be due to the operator, the workload, the means of production and the work environment [9]. These categories are interdependent, coexisting in time and space, constituting the work system, within which work processes are carried out. As a result, to identify the causes of accidents and occupational diseases at the level of a workplace, it is necessary to analyze what happens inside the system [10].

To carry out this research, in the first stage, certain theoretical and methodological aspects applied in previous research were analyzed. Currently, the measuring equipment for the parameters that characterize a workplace's work environment has also been greatly developed. For example, modern science and technology have provided effective solutions for real-time monitoring of temperature [11] and vibrations [12].

For a more complex picture of the physical environment, the working environment, the list of risk factors specific to the working environment includes the following air characteristics, such as: temperature, humidity, pressure, air ionization, current level. To these are added: noise, vibrations, the presence of ultrasound, lighting, the level of radiation (electromagnetic and ionizing), electrostatic potential, the presence of possible chemical factors, respectively other special characteristics. The specialized literature also considers within the category of risk factors specific to the working environment those of a biological nature, respectively the risks of psychophysiological overload of the operator [13].

For the current research, the physical factors of the working microclimate in electrical and electronic manufacturing units were considered.

One of the essential problems of monitoring parameters is also related to the performance of work equipment, measurement precision. Following such research, the aim is also to find an integrated solution for surveillance and monitoring of the work environment.

The research itself was also based on the degree of dissatisfaction of the operators (evaluated by the number of complaints, notifications), as well as on the evolution of the number of cases of

accidents and occupational diseases, registered in the last 5 years at workplaces, in electrotechnical and electronic manufacturing located in Timiș County.

The diversity of situations was considered, in conjunction with the technical specificity and work tasks, which had a common set of physical characteristics.

The research strategy is oriented towards identifying preventive measures necessary to reduce the degree of danger at workplaces. It should be noted that the workplaces chosen for the research were in indoor spaces, as is almost entirely the case in the manufacture of electrotechnical and electronic products.

The research method included 3 stages: establishing the perspective of risks for the health of operators, identifying the most important risk factors associated with the work environment and establishing optimal intervention measures, which would determine the reduction of the risks of occupational accidents or diseases [14].

The evaluation was carried out in various workplaces, aiming to approximately cover most possible situations in the chosen manufacturing field. The criterion for the greatest possible dangers in these situations was also considered, selecting workplaces where there were more problems reported, respectively where more cases of illness were recorded.

Certain situations were also considered in which the technological process requires a certain level of humidity in the workplace. In these cases, it is necessary to have a controlled environment in which the level of relative humidity, without the operator having to endure additional stress [15].

During the research, in selecting the technical means of measurement, the evolution of the market of measuring and control instruments was also monitored, which is highly segmented by field of use. In recent years, electrotechnical and electronic products have diversified greatly, an important sector being represented by components and assemblies intended for obtaining renewable energy, respectively for charging electric vehicles.

3. EXPERIMENTAL RESEARCH

An experimental program was carried out, consisting of measurements carried out periodically (quarterly) for 3 years (2020, 2022 and 2024), at 54 different workplaces. It should be noted that the measurements were carried out in 2020 only annually, once, in 2022 the checks were carried out semi-annually, and in 2024 quarterly.

Before the measures were carried out, a selection of the performing laboratories was made, in relation to the performance level of the equipment used. The certificates of authorization, granted by the *National Institute of Public Health*, Regional Center of Public Health Timisoara, regarding the competence to carry out the established determinations were checked. Also, the certification documents for the metrological verification of the equipment were identified. The calibration certificates issued by laboratories subordinate to the National Institute of Metrology were checked.

For each measured characteristic, measurement procedures were established, in accordance with the norms approved by the state institutional authority.

To establish the research program, specialized institutions and persons authorized to certify certain parameters for assessing environmental conditions at a workplace were consulted. The methodology and working methods for controlling working conditions and the level of harmful substances in work areas are in accordance with the legislation in force, based on Law no. 319/2006 - on Occupational Safety and Health. Thus, the government decisions (GD) were respected: H.G. 493/2006 - on minimum safety and health requirements regarding noise and SR EN ISO 9612 of September 2009, with H.G. 1218/2006 - on establishing minimum safety and health requirements for ensuring the protection of workers against risks related to the presence of chemical agents, amended with H.G. 1/2012, as well as Annex 1, regarding permissible limit values for dusts without specific effect from H.G. 359/2015, in accordance with SR EN 82/2010 and SR EN 689/ 2003.

The following types of measurements were performed:

3.1. Air temperature

The air temperature in the work area was recorded with a thermocouple thermometer with 2 type K probes and 2 rigid probes, with a measurement range of -50[0C] - +250[0C], with updated metrological certification at the time of application. Thermal stress was monitored through the values of the WBGT index (Wet Bulb Glob Temperature). For sampling for air microclimate monitoring - thermal stress, the Delta OHM 323 microclimate equipment, GFTB 100 hygrobarometer, was used. Air samples in the work area were taken at the worker's respiratory level.

3.2. Air pressure

Recorded with a digital manometer, with values expressed in [hPa]

3.3. Humidity

With determination of relative humidity, expressed in percentages, [%]. A digital thermohygrometer was used. The degree of humidity imposed technologically in the workspace was also considered.

3.4. Noise level measurement (occupational acoustic field)

To measure the noise level, the CEL 632C device with A, C and Z weighting networks was used. Also, a noise dosimeter (12 dBadge2, acoustic calibrator CEL 120, manufacturer Casella CEL Anglia). It was measured during 8 hours of work; the dosimeter being placed on the operator's shoulder at 10 cm from his ear.

3.5. The speed of air currents

The speed of air currents was measured using a professional anemometer TROTEC TA300 and expressed in [m/s].

3.6. Determining the presence of occupational noxious substances by determining biotoxicological indicators.

The presences of the following were determined: - carbon monoxide, oxygen, hydrogen sulfide, methane, volatile organic compounds - VOCs (benzene, toluene, naphthalenes, acetylenes, butadienes, vinyl chloride, acetone, trichloroethylene, methyl alcohol, chloroform, isopropyl alcohol, butyl alcohol, gasolines - fuels, ethyl alcohol.

3.7. The lighting

The lighting was recorded with a portable professional luxmeter, model DELTAOhm HD2302, with interchangeable sensors.

3.8. Determination of the presence of dust, inhaling and respirable fractions.

Sampling for the determination of respirable dust was carried out on a 5 pnn PVC filter brought to constant mass. For sampling, the following were used: APEX 8 pump, Higgins-Dewell cyclone, GE700C rotameter, Conrad electronic thermohygrometer and for analysis, a METTLER MS205DU/M analytical balance was used. The method used was NIOSH 0600, PTL-66. Concentrations were expressed in mg/m 3, reported at a temperature of 293 K and a pressure of 101.3 kPa.

The harvesting conditions (environment), during the measurement period, were correlated with the temperature, pressure and humidity recorded.

The microclimate hazard analysis reports were developed based on: PR 02; PR04; PR05 - IL 03, respecting the procedures established by SR EN 82/2010 and SR EN 689/ 2003, SR EN ISO 7730:2006, SR EN 27243:1996, SR EN ISO 7726:2004 and other related ones.

4. RESULTS

The measurement results were centralized. They were analyzed at the level of each workplace. After each package of verification of environmental conditions, recommendations, technical-organizational measures, technical and organizational measures were sent to the management team.

The most frequent corrective measures referred to ensuring adequate general and local ventilation, equipping operators with individual protective equipment appropriate to the workplace.

There were several references to aspects regarding the health of operators, establishing medical measures, such as: frequent medical checks upon employment, monitoring the adaptation medical check and performing periodic medical checks.

In the case of exceeding the noise level, measures were established to identify the source, followed by eliminating or reducing the intensity. It was also recommended to perform audiometry for employees exposed to noise above 80 dB(A). Where noise exposure exceeded 87 dB (A), respectively the maximum value of the unweighted instantaneous acoustic pressure exceeded 200 Pa, the employer was recommended to train workers on the potential risks to hearing due to noise exposure, and workplaces had to be marked with signs indicating that wearing individual protectors (headphones, earmuffs) is mandatory.

After centralizing the recorded results, an analysis was made on the situations of exceeding the values of the measured parameters, compared to the values recommended in the standards in force. Also, the number of notifications, complaints and cases of occupational illness were centralized, having as a cause each characteristic separately. Thus, the situation presented in table 1 resulted.

Table 1 - Situation of exceeding the permitted limits and the recorded effects

Measured characteristic		*No. Deviations determined by measurements*	*No notifications, complaints, occupational illnesses*
Air temperature, [^{0}C]	2020 – Yearly	16	25
	2022 - Semesterly	19	19
	2024 – Quarterly	20	7
Air pressure, [hPa]	2020 – Yearly	8	6
	2022 - Semesterly	12	5
	2024 – Quarterly	14	0
Relative humidity, [%]	2020 – Yearly	19	8
	2022 - Semesterly	21	7
	2024 – Quarterly	26	2
Noise, [dB]	2020 – Yearly	14	36
	2022 - Semesterly	19	25
	2024 – Quarterly	28	9
Airflow speed, [m/s]	2020 – Yearly	9	6
	2022 - Semesterly	11	4
	2024 – Quarterly	15	2
Presence of toxins Biotoxicological indicators	2020 – Yearly	16	24
	2022 - Semesterly	24	15
	2024 – Quarterly	39	7
Lighting, [lux]	2020 – Yearly	5	11
	2022 - Semesterly	10	8
	2024 – Quarterly	14	4
Powders, inhalable and respirable fractions	2020 – Yearly	15	26
	2022 - Semesterly	27	18
	2024 – Quarterly	28	9

From the data in the table, it is observed that, in the case of all measured characteristics, increasing the frequency of checks, with the application of the related corrective measures, reduces the number of dissatisfactions and occupational illnesses. From the records existing in the human resources departments, it was found that, during the research period, in which the management teams were involved in more careful supervision of the workplaces, the number of departures from companies due to the environmental conditions in which they carried out their activity was reduced.

5. CONCLUSION

The research proved to be effective in terms of increasing the interest of company management in continuously improving the working conditions of employees in the field of manufacturing electrical and electronic products, but also in the interest in better monitoring the characteristics of the working environment at workplaces. From the discussions held with those responsible for Occupational Health and Safety, as well as those responsible for occupational medicine, it was found that there is a need for better collaboration with the departments of conception, design and work organization for a better modeling of the landscape of social responsibility, through the real modernization of workplaces.

The results of the research are intended to be helpful in guiding organizations in improving ethical, legal and socially responsible behavior, aiming not only at the economic performance of the company, but also at determining a state of satisfaction and well-being of employees.

In the future, it is considered necessary to pay greater attention to the technical solution of the permanent monitoring of the working environment at workplaces, with an immediate warning of exceeding the limits of safety parameters.

The paper does not fully solve the broad issue of optimizing the working environment of workers in the electrical and electronics industry, but the findings may contribute to improving working conditions, but, by automating the monitoring, some employee-employer communication barriers are eliminated, regarding the reporting of dissatisfaction and the risk that the employee will lose his job due to the audacity to express his dissatisfaction. In essence, it is considered important that this study covers some facets of the complexity of the relationship between ethics, law and social responsibility, so necessary at every workplace.

6. REFERENCES

[1] Drăghici, A., Căruțașu, N., Ivașcu, L. Operational risk management, Ed. Politehnica Press București, 2019, ISBN 978-606-554-067-5.

[2] https://single-market-economy.ec.europa.eu/sectors/electrical-and-electronic-engineering-industries-eei_en

[3] https://www.effivity.com/blog/improve-risk-management-at-workspace

[4] https://www.burohappold.com/articles/10-environmental-factors-improve-wellbeing/

[5] Milenković, I., Milenković, N., Exposure to chemical agents and assessment of occupational risks, Proceedings of the International Multidisciplinary Conference „Challenges of Contemporary Higher Education" - CCHE 2024, vol. 2, pag. 64-68, 2024.

[6] Karić, S., Rešetar, D., Bojić, Ž., Ethics, law, and social responsibility: navigating health and safety-related dilemmas in the workplace, Proceedings of the International Multidisciplinary Conference „Challenges of Contemporary Higher Education" - CCHE 2024, vol. 2, pag. 351-358, 2024

[7] Spaić, S., Savić, B., Investigation into the new law on occupational safety and health at work, Proceedings of the International Multidisciplinary Conference „Challenges of Contemporary Higher Education" - CCHE 2024, vol. 3, pag. 386-393, 2024.

[8] Galjak, M., Nikolić, V., Trumbulović, L., Nikolić., B., Šapić, R., The connection between the quality of the environment and the quality of life, Proceedings of the International Multidisciplinary Conference „Challenges of Contemporary Higher Education" - CCHE 2024, vol. 3, pag. 361-367, 2024.

[9] Occupational Health and Safety, Romanian Law No. 319/2006, as amended and supplemented in 2023.

[10] Băbuț, G.B., Moraru, R.I., (2013). Critical analysis and ways to improve the I.N.C.D.P.M. Bucharest risk assessment method for occupational accidents and diseases. Quality - Access to

Success, Volume 14, Issue 137, pg. 113-120, http://www.scopus.com/inward/record.url?eid=2-s2.0-84889564558&partnerID=MN8TOARS

[11] Halas, D., Eremić, Ž Sari, Monitoring and controlling the temperature using a microcontroller, Proceedings of the International Multidisciplinary Conference „Challenges of Contemporary Higher Education" - CCHE 2024, vol. 1, pag. 409-413, 2024

[12] Antunović, R., Savić, B., Monitoring and vibration testing of machines, Proceedings of the International Multidisciplinary Conference „Challenges of Contemporary Higher Education" - CCHE 2024, vol. 3, pag. 20-26, 2024

[13] European Agency for Safety and Health at Work. Research on work-related MSDs. https://osha.europa.eu/ro/themes/musculoskeletal-disorders/research-work-related-msds, September 2023

[14] Jahagirdar, R. & Bankar, S. (2020). Employees Perception of Workplace Monitoring and Surveillance. PEOPLE: International Journal of Social Sciences, 6(1), pg. 474-486.

[15] La Torre, G, Esposito, A., Sciarra, I., Chiappetta, M. (2018). Definition, symptoms and risk of technostress: a systematic review, International Archives of Occupational and Environmental Health, volume 92. pg. 13–35, https://doi.org/10.1007/s00420-018-1352-1.