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OCCUPATIONAL RISK ASSESSMENT FOR MAINTENANCE ELECTRICIANS WITHIN AN AUTOMOTIVE PRODUCTION COMPANY

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Abstract: This work represents an attempt to highlight, in a concise form, through accessible arguments, combined with scientific rigor, the potentiality of methods for evaluating occupational risk factors for the "Maintenance and Repair Electrician" job. At the same time, we tried to capture, in a broad, relational, systematic, concise, but also attractive framework, the essential aspects of the assessment of the risk factors found at the level of workplaces within the investigated company. The aim was to offer an interesting perspective, in the aspect of a particular vision of the organizational reality or a new paradigm regarding the impact of the assessment of risk factors on competitive success, which would bring a genuine increase in knowledge, facilitate the understanding of the respective issue or the new reference for explaining organizational performance and to have relevance for the professionalization of activities in the field.

Key words: risk at work, injury and occupational illness, maintenance electrician, automotive industry.

1. INTRODUCTION

Any organization operating in an environment that influence the risks but creates at the same time, a context that fixes the limits within which risks must be managed [1], [2], [3]. Moreover, each organization has partners relying on their approach for achieving the goals [4], [5] As emphasized by Moraru et al. (2011, 2014), an effective risk management for occupational health and safety (OHS) must take into account the priorities established by the partners too with respect to risk management processes [6], [7]. Therefore, the environment in which the organization subsists is not neutral. In theory and practice devoted to risk we are speaking even about the extended organization (at the level of the interacting environment) [8]. Risk management must be subordinated to the objectives that form an integrated, coherent and converging system, towards the overall objectives, so that activity levels to support each other [9], [10], [27], [29], [31].

This approach allows the organization to define and implement a risk management strategy that starts from the top and is integrated into routine activities and operations of the organization. In all working systems and all the jobs the employer has

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a general duty to protect the life, integrity and health of workers against occupational hazards that may occur in the workplace and create working conditions designed to ensure their physical, psychological and social comfort. [11], [12]. Adoption by the employer, within its responsibilities, of prevention and protection measures aimed at preventing occupational risks, information and training of workers and ensuring the organizational framework and means required for health and safety at work imposes to perform the occupational risk assessment [13]. Therefore, it can be stated that the primary goal of occupational risk assessment is always prevention of occupational risks, even if this objective is not always achievable in practice [14]. Where it is not possible to eliminate hazards, risks should be reduced so that the residual risks are kept under control [15]. In later stages and under a rigorous control program, residual risks will be reassessed, analyzing the possibility to further eliminate or reduce them, following developments in scientific and technical knowledge [16], [28], [30], [34].

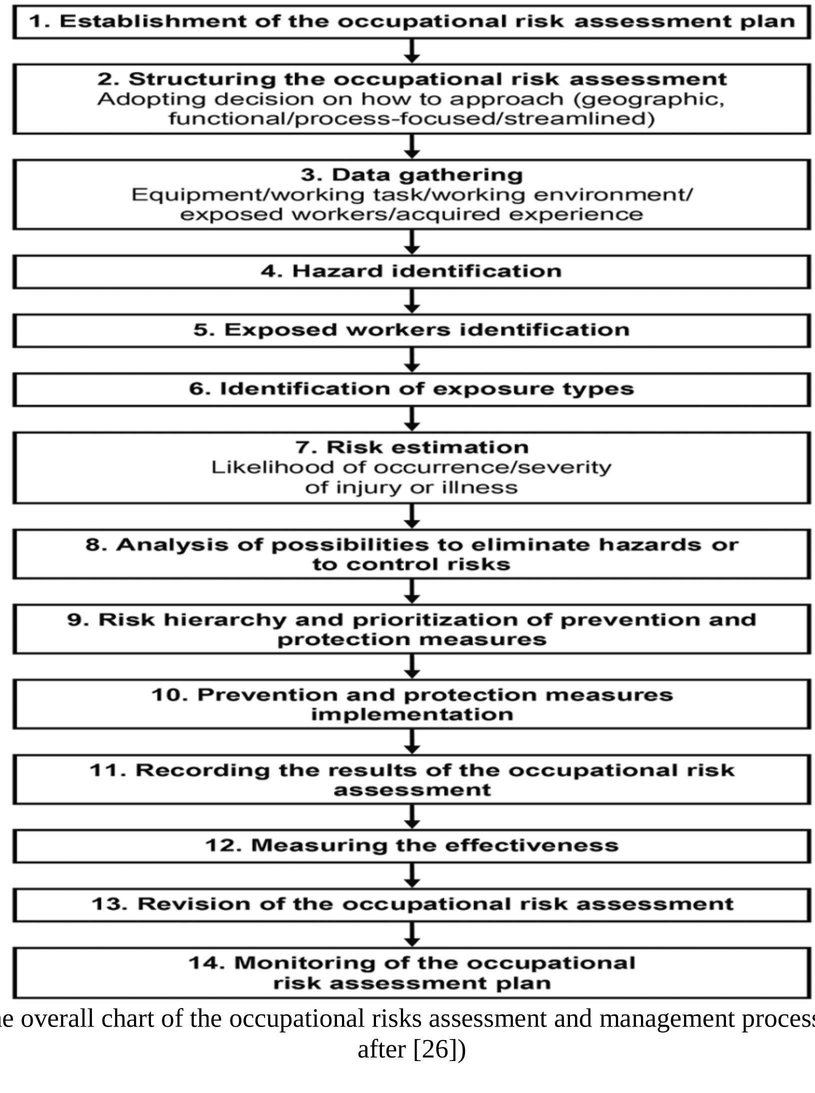

Fig.1. The overall chart of the occupational risks assessment and management process (adapted after [26])

Starting from the legislative, normative and methodological requirements, it can be stated that the occupational risk assessment is the systematic study of all aspects of the work process that are likely to generate unwanted events, of the means of eliminating hazards and applicable prevention and protection measures to control the associated risks [17], [18], [19], [20].

The assessment should cover the occupational risks that are reasonably foreseeable. Risks resulting from day-to-day activities are normally considered insignificant and require no special attention unless professional activity implies their aggravation [21]. The methodology and criteria for assessing occupational risks must be defined according to the scope, nature and time scheduling to ensure they are proactive rather than reactive and are used in a systematic manner [22]. Organizations can use different risk assessment methods as part of their global strategy to deal with various hazards or activities. The complexity of the risk assessment method does not depend on the size of the organization but on the hazards associated with the organization's activities. Figure 1 presents the general chart of the occupational risk assessment process that includes some elements of occupational risk management [23], [32].

To be effective and sustainable, the risk assessment process should be simple, practical, and easy to understand. Its success highly depends upon management commitment, involvement and adequate resources allotment [24]. The process should be performed by people with proper skills supported by technology that is correctly sized for the working task. Risk assessment must be part of a larger framework that uses the information gathered to make decisions about risk responses and monitoring, and returns information back into the overall strategic planning process [25], [33].

2. WORK PROCESSES IN THE INVESTIGATED COMPANY

Commercial company S.C. XYZ ROMANIA LLC. is located in the N-E part of the ABC municipality, and owns the site of 6.75 ha of the headquarters, the built surface is Ac = 14,490 m^2 and the developed surface is Ad = 16,320 m^2. The company provides its employees with appropriate spaces for carrying out their activity, environmental motivations for quality services. Activity profile: CAEN code 2932 - ***manufacture of other parts and accessories for motor vehicles and motor vehicle engines***. Number of employees: 551 . They carry out their activities in the main headquarters, as follows:

a) ***Company management and support departments***:
   - Secretariat;
   - Technical office: HSE (Safety and health at work, Emergency situations and Environment);
   - Human resources office;
   - Financial office - accountant;
   - Archive;
   - Engineering;
   - IT;
   - Logistics office;

- Personal training rooms;
- Dining room;
- Changing rooms-lockers;
- Medical office.

b) ***Production/manufacturing departments****:*

1. Warehouse raw materials production space
2. BPP sector (sandblasting, adhesive application)
3. Press sector
4. Clamping/unclamping sector
5. Ovens sector
6. GSP sector
7. Accessories sector
8. Packaging sector
9. Finished product warehouse sector
10. Quality laboratory
11. Maintenance

The specific activities of each section are carried out based on the work procedures and integrated management plans for quality, environment, safety and health at work, established for each of them within the implemented SMI (integrated management system).

c) ***Technical space annexes****:*

- Compressor technical space;
- Thermal power plant technical space;
- Electricity transformer building;

d) ***Warehouses:***

- Storage of chemical materials;
- Storage of raw materials;
- Residuary wastes.

Description of activities:

The production hall, the property of the company, is authorized and approved by the local administration bodies, sanitary, the authority for environmental protection, fire safety and safety and health at work, in an area of 11,564 square meters. The following sections are organized in this space:

1. Raw material warehouse section for production space

The raw material warehouse for production space is equipped with 3 forklifts and 3 electric forklifts that also serve the production sector, shelves for storing raw materials and materials. Also here is the installation to send the mix to the press bunkers. In this warehouse, the raw material (mix, metal plates, chemicals, etc.) is received, a preliminary quality check is made and they are placed on the shelves (fig.2).

Fig.2. Raw material warehouse section for production space

2. Section BPP sandblasting adhesive application

The BPP sandblasting and adhesive application section receives the plates from the raw material warehouse, it is equipped with a plate sandblasting plant, an adhesive application plant, a plate heating oven, a cooling oven, a conveyor belt, a plate recovery tank, shelves for keeping sandblasted plates and for which the adhesive was applied. The metal plates are sandblasted, then a layer of adhesive is applied, they go through the oven and then the cooler, then they are transported to the press section (fig.3).

Fig.3. Section BPP sandblasting adhesive application

3. Presses section

At the press section there are 2 types of pressing procedures:

- Hot pressing: FHP presses, 3 pieces
- Cold pressing: FSP presses, 6 pieces, KZP 4 pieces, SSP 2 pieces.

The plates coming from the adhesive application section are placed in the press warehouse, the mix is brought through pipes from the warehouse to the hopper, and the pressing operation is done automatically (fig.4).

Fig.4. Section „presses"

4. Clamping/unclamping section

The clamping/unclamping section contains 10 workstations. When clamping, they are fixed in frames to prevent expansion in the ovens, then they are placed in the oven at a temperature lower than 300°C and left for a few hours for the baking process. Then they are put into the cooler where they are removed from the frames (fig. 5).

Fig.5. Clamping/unclamping section

5. Furnace section

Furnace section contains a number of 6 ovens where the plates are inserted into the oven at a temperature lower than 300°C and are left for a few hours for the baking process (fig. 6).

Fig.6. Furnace section

6. GSP section

The GSP section has 5 production lines. At GSP, the first process is the grinding process, where the edges of the plates are made (they are ground), then on the metal side, the back of the plate, a paint is applied in an electrostatic field (in painting booths), then the plates are inserted into the painting oven (paint oven) then follows the cooler and the rotary table from where they are taken manually by the operator. At GSP, the plates are transported between processes on a conveyor belt (fig.7).

Fig.7. GSP section

7. Accessories section

The accessory section has 10 work lines. For accessories, various accessories are applied on the back of the plates, the sensor (only on certain types) 10 work tables, 10 devices for inscription, 10 stations with operators who mount accessories and inscribe the barcode and company logo on the plate (fig.8).

Fig.8. Accessories section

8. The packing department

The packing section has 3 work lines, consisting of work tables, box support stacks. When packing, the pairs of plates are put into boxes, along with the instructions, the boxes are closed and sealed, checked and ready for delivery. At each section and completion of operation or process there are stations for checking product operations by quality checkers (fig.9).

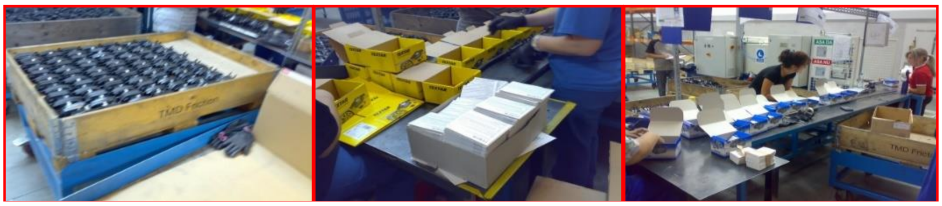

Fig.9. The packing department

9. Finished Product Warehouse Section

The product warehouse is equipped with 2 forklifts and 2 electric forklifts that also serve the production sector, shelves for storing finished products. At the finished product warehouse, the products are placed in transport boxes and the rolls are loaded for transport (fig. 9)

Fig. 9. Finished Product Warehouse Section

10. Quality Laboratory Section

At the quality laboratory, specific tests are performed (friction, detachment, etc.) being equipped with devices and equipment for performing tests and checks (fig. 10).

Fig.10. Quality Laboratory Section

11. Maintenance Section

The maintenance department is equipped with welding machines (electric and autogenous), drilling machine, cutter with abrasive stone (fixed and mobile), grinder, welding table, lathe, planer, milling machine, grinding machine, tool kit, air compressor, workbenches, vices, sandblasting machine etc. The maintenance section provides repairs and interventions to production machinery in the event of defects, malfunctions in the process and technological flow (fig.11).

Fig.11. Maintenance Section

The jobs that were analyzed and for which the risk assessment for safety and health at work was carried out are presented in table 1.

*Table 1. **The list of jobs for which the risk assessment was carried out***

Nr. crt.	Job/workstation	Number of workers
1.	Operator of industrial robot presses FSP - CAEN code 817001	27
2.	**Maintenance and repair electrician - CAEN code 724507**	7
3	Mechanical locksmith - CAEN code 721424	4
Total		38

3. ASSESSMENT OF INJURY AND OCCUPATIONAL DISEASE RISKS FOR THE MAINTENANCE AND REPAIR ELECTRICIAN

The purpose of the work process is to check, maintain and repair the electrical installations within the unit. Figures 12, 13 and 14 show some of the identified forms of manifestation of specific risks. Applying the tools and the procedure specific to the INCDPM Bucharest method [26], the concrete forms of manifestation of the risks were identified, the severity classes and the probability classes related to each of the identified risks were assigned, and then - using the scale of framing the risk levels, the partial risk levels were set.

The results obtained are centralized in Table 2. The meaning of the notations in table 2 is as follows:

- *WSE - Work system element; IR - identified risk; RF – risk factor; MC - Maximum consequence; S - Severity; Likelihood; RL - Risk level; WE - Working equipment; OE - Occupational environment; WT - Working task; HF - Human factor;*
- *N-negligible; LTI 3-45 – Lost Time Injury from 3 to 35 days; LTI 45-180 – Lost Time Injury from 45 to 180 days; INV I – first degree invalidity; INV II – second degree invalidity; INV III – third degree invalidity; D – death.*

Fig.12. Machine parts in motion - hand grip when placing the plates in the magazine.

Fig.13. Projection of dust mix in the eye, particles carried by the air currents to the abrasive belt, dropping-jumping pads

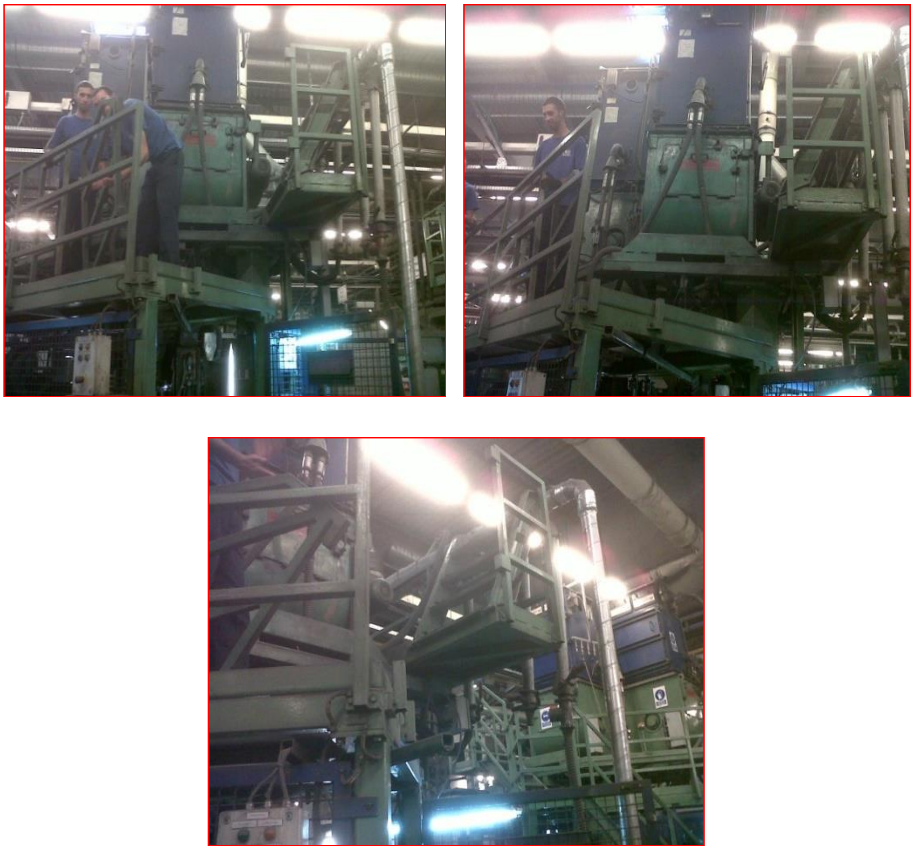

Fig.14. Falling from a height due to imbalance, slipping, tripping – when checking the level of mix in the mix in the hopper, when manually loading and emptying the hopper

*Table 2. **Risk Assessment Card for „Maintenance Electrician”***

<table>
<tr><td colspan="2">UNIT: S.C. XYZ LLC.</td><td rowspan="3">WORKPLACE EVALUATION SHEET</td><td colspan="4">Number of people exposed: 7</td></tr>
<tr><td colspan="2">DEPARTMENT: Maintenance</td><td colspan="4">Duration of exposure: 8 h/shift</td></tr>
<tr><td colspan="2">Workstation: Electrician de întreținere și reparații 724507</td><td colspan="4">Evaluation team: Administrator, Head of maintenance, Head of internal OSH service, Occupational medicine doctor</td></tr>
<tr><td>WSE</td><td>IR</td><td>Risk Factors</td><td>MC</td><td>S</td><td>L</td><td>RL</td></tr>
<tr><td rowspan="2">WE</td><td rowspan="2">Mech. RF</td><td>1. Machine parts in motion - grip, drive by transmissions with couplings, with belts.</td><td>INV III</td><td>4</td><td>2</td><td>3</td></tr>
<tr><td>2. Movements of means of transport - hit by means of transport - access to the</td><td>INV III</td><td>4</td><td>1</td><td>2</td></tr>
</table>

		workplace by means of vehicles				
		3. Dangerous surfaces or contours – direct contact of the epidermis with cutting, prickly, slippery surfaces	LTI 3-45	2	5	3
	Thermal RF	4. Lowered temperature – cold metal surfaces touched directly	LTI 3-45	2	6	3
		5. Flames from the accidental priming of the electric arc in the switching devices.	**D**	7	1	3
	Electric RF	6. Electrocution by direct contact	**D**	7	2	4
		7. Electrocution by indirect contact or by the appearance of step voltage	**D**	7	2	4
	Chemical RF	8. Flammable substances, adhesive, adhesive solution, paints, thinners	LTI 45-180	3	3	3
OE	Physical RF	9. High relative air humidity	LTI 3-45	2	6	3
		10. High noise level especially in the test bench area	INV III	4	2	3
		11. Low lighting level – lack of lighting lamps	INV III	4	2	3
	Chemical RF	12. High level of exhaust gases, etc.	**D**	7	1	3
WT	Physical overload	13. Forced working positions.	LTI 3-45	2	6	3
		14. Dynamic effort – long intervention route, repeated movements between machines.	LTI 3-45	2	5	3
	Mental overload	15. Difficult decisions in a short time made in an environment of noise and exhaust gases.	LTI 3-45	2	5	3
HF	Wrong actions	16. Execution of works that exceed the competence or authorization of the worker	**D**	7	2	4
		17. Actions due to erroneous identification of equipment elements	**D**	7	2	4
		18. Out of sync when working in a team	LTI 45-180	3	2	2

		19. Falling on the same level by unbalancing, slipping, tripping – slippery, uneven surfaces	LTI 45-180	3	3	3
		20. Falling from a height on the nacelle, by stepping in the void, unbalancing or slipping	**D**	7	1	3
	Omissions	21. Failure to use personal protective equipment: electrical insulating boots, electrical insulating gloves, protective helmet and visor	**D**	7	2	4

The overall risk level of the job is:

$$N_{rg} = \frac{\sum_{i=1}^{21} r_i \cdot R_i}{\sum_{i=1}^{21} r_i} = \frac{5\cdot(4\times4)+14\cdot(3\times3)+2\cdot(2\times2)}{5\times4+14\times3+2\times2} = \frac{214}{66} = 3{,}24 \quad (1)$$

The partial levels of risk by risk factors are represented graphically in fig. 15, the prevention and protection measures intended to minimize the risks located in the unacceptable field being centralized in table 3.

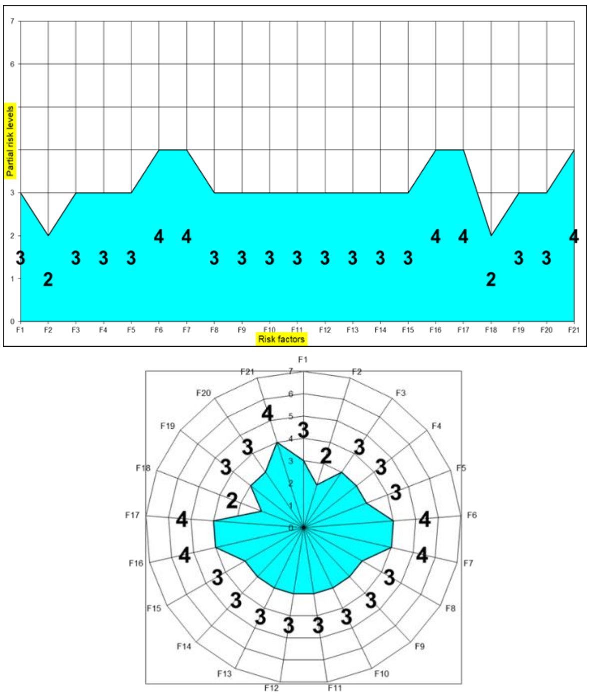

Fig.15. Partial risk levels by risk factors at work: maintenance and repair electrician

Table 3 . **Sheet of proposed measures: "Maintenance and repair electrician" workplace**

Risk factor	Risk level	Proposed measures
F06 - Electrocution by direct contact	4	***Technical measures***: • identification of the installations to be worked on; • visual check of the integrity of the electrical conductor insulation; • the use, as appropriate, of a head protection helmet, a face protection visor, electro-insulating gloves, electro-insulating shoes or carpet and tools with an electro-insulating handle; • execution of technical security measures by trained and authorized personnel. ***Organizational measures***: • training and authorization according to the legal provisions in force, as well as periodic testing of the technical and work safety knowledge acquired by the executor; • execution according to the authorized procedures of all interventions, regardless of their nature; • periodical control with the aim of complying with electrical safety measures.
F07 - Electrocution by indirect contact or the appearance of step voltage	4	***Technical measures:*** • visual check of the integrity of the grounding of the equipment casings, poles and metal and concrete supports in the work area • discharging the capacitive load of the installation to be worked on; • the use, as appropriate, of electro-insulating gloves, shoes or electro-insulating carpet and tools with an electro-insulating handle.
F16 - Execution of works that exceed the competence or authorization of the worker	4	***Organizational measures***: • the duties of the maintenance electrician will include only activities for which he is authorized and trained; • for interventions that exceed the competence or authorization of the maintenance electrician, natural or legal persons with the necessary competence will be contacted.
F17 - Actions due to erroneous identification of equipment elements	4	***Technical measures***: • all interventions performed on the electrical installations will comply with the provisions contained in the technical books of the equipment. ***Organizational measures***: • the maintenance electrician will be periodically trained on how to operate the technical equipment used by the unit in the production process.

F21 - Failure to use individual protective equipment and other protective means provided	4	***Technical measures:*** • equipping workers with individual protective equipment corresponding to the activity to be carried out. ***Organizational measures***: • wearing protective equipment will be mandatory.

4. INTERPRETATION OF RISK ASSESSMENT RESULTS

The global risk level calculated for the job "*Maintenance and repair electrician*" is equal to 3.24, a value that places it in the category of jobs with a low to medium risk level, not exceeding the maximum acceptable limit (3.5).

The analysis of the data from the "Assessment Sheet" highlights the fact that out of the total of 21 risk factors identified, only 5 exceed, as a partial level of risk, the value of 3, 5 falling into the category of medium risk factors.

The risk factors that are in the unacceptable range are:

- F06 - Electrocution by direct contact – partial risk level 4;
- F07 - Electrocution by indirect contact or the appearance of step voltage - partial risk level 4;
- F16 - Execution of works that exceed the competence or authorization of the worker - partial risk level 4;
- F17 - Actions through erroneous identification of equipment elements - partial risk level 4;
- F21 - Non-use of individual protective equipment and other protective means provided - partial risk level 4.

In order to reduce or eliminate the 5 risk factors (which are in the unacceptable field), the generic measures presented in the "Proposed measures sheet" are necessary.
The distribution of risk factors by generating sources is presented as follows (fig. 16):

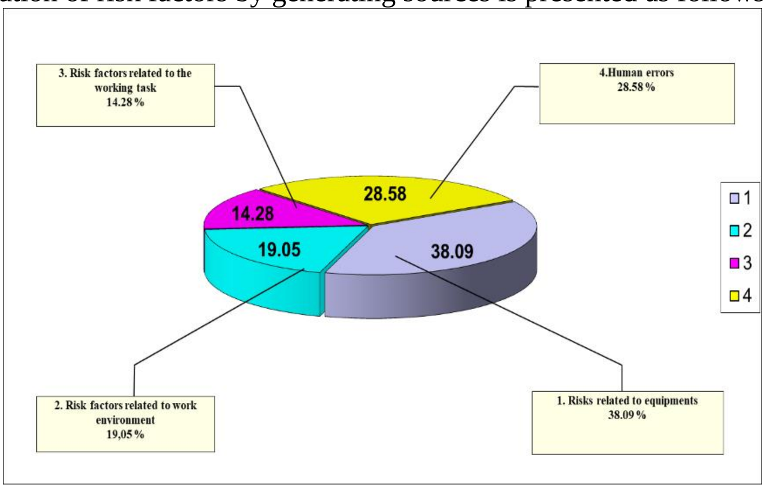

Fig.16. The share of risk factors identified by the generating source

- 38.09%, factors specific to the work equipments;

- 19.05%, factors specific to the work environment;
- 14.28%, factors specific to the workload;
- 28.58%, human factors.

From the analysis of the Risk Assessment Card, it is found that 38.10% of the identified risk factors can have irreversible consequences on the performer (death or disability), so that the workplace cannot be classified among those with a particular risk of injury.

5. CONCLUSIONS

The work concerned the assessment of risks for the job "Maintenance and repair electrician" within an industrial company in the automotive field, in accordance with the provisions of art. 7, para. 4, lit. b, art. 12, para. 1, lit. and art. 13 of Law no. 319/2006 and art. 15, para. 1, points 1 and 2 of H.G. no. 1425/2006.

The risk assessment was carried out on the basis of the data provided to the investigated company through the job descriptions, the lists of technical equipment, their technical books, the regulations for granting individual protective equipment, information about technological processes and the development of the work process for each job, received from the management and technical staff of the company, as well as the own observations made during the documentation visits and follow-up of the activity for each workplace.

The list of jobs evaluated in the overall research is shown in table 4.

Table 4. ***The centralizer of the results of risk assessments at the investigated company***

Crt. No.	**No. card**	**Workstation**	**Overall risk level**
1	F01	Operator of industrial robot presses FSP 817001	3,11
2	F02	**Maintenance and repair electrician 724507**	3,24
3	F03	Locksmiths 721424	3,23

The overall risk level per company is:

$$N_{gs} = \frac{\sum_{i=1}^{3} r_i \cdot N_{gi}}{\sum_{i=1}^{3} r_i} = 3{,}19 \qquad (2)$$

According to the ranking, it is found that all jobs have a global risk level below the allowed limit (3.5), they fall into the category of those with a low to medium risk level. The value of the aggregate global risk level per company N_{gS} = 3.19, determines its inclusion in the category of those with a low to medium risk level.

The ranking of workstations, depending on the overall level of risk, is shown in table 5.

Table 5. ***Risk ranking***

Crt. No.	**No. card**	**Workstation**	**Overall risk level**
1	F01	**Maintenance and repair electrician 724507**	3,24
2	F02	Locksmiths 721424	3,23
3	F03	Operator of industrial robot presses FSP 817001	3,11

The realization of the work consisted in going through the following stages: analysis of the activities carried out within the company; establishing the workplaces for which the risk assessment for safety and health at work was carried out; identification of risk factors for each job; establishing the maximum foreseeable consequence of the action of the risk factors on the human body, for each individual risk factor; classification into gravity classes; classification into probability classes (frequency); determination of the partial risk level for each identified risk factor; calculation of the global risk level for each job; interpretation of the results of the risk assessment for safety and health at work for each workplace, through the lens of current legislation; preparation of measures sheets for each workplace, for risk factors that exceed the acceptable level.

In the current activity of the investigated company, the employer has always shown the conviction that the success, performance and competitiveness of the modern organization depend, to a large extent, on the integration of the assessment of risk factors into the business strategy, beyond the legal provisions that require this or the threat of stopping the activity or fines applied by labor inspectors. Beyond these considerations, the discrepancies also reflect the shock produced by an interdisciplinary, relatively new field of concern and action on a society, not always sufficiently prepared in terms of information, but also of the lack of multiple choices, therefore of knowledge and receptivity to new and change.

Through this paper, we tried not only to present an aspectual assessment, from the point of view of the occupational safety and health field, of a workplace, but also to satisfy the need for information on the activity profile as a whole and to cover a void strongly felt in the specialized literature. Because of claims, often apathetic, lacking in depth, of false conditioning focused only on one method, of obvious mistrust, of the perpetuation of de facto resistance or lack of specialized literature, translated into Romanian, it should not be limited the action and not diminished the tendency of the assessment of professional risk factors to integrate more and more deeply in the organizational management, in general, or even in the management of human resources in particular, beyond the activities of the Internal Service of Prevention and Protection, as one of the modern directions of their development.

The paper invites to analysis, provokes reflection and hopefully interest, while being susceptible to improvement and development, and some of the issues and aspects require continuous improvement and examination. The work is, however, a point of departure and analysis of research that is based on reducing the risk and reducing the occurrence of work accidents.

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