

ANALYSIS OF OCCUPATIONAL RISKS FOR THE JOBS “PHOTOVOLTAIC PANELS INSTALLER”, “INDUSTRIAL ROBOT OPERATOR” AND “FORKLIFT OPERATOR” AT ALTIUS PHOTOVOLTAIC LLC GIURGIU

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Abstract. This paper aims to identify, assess and treat the risks of occupational accidents and diseases for workers within S.C. Altius Fotovoltaic S.R.L., Giurgiu, as well as to identify the prevention and protection measures necessary to create a safe working environment. The aim is to highlight the importance of occupational risk assessment within the company. By highlighting the importance of occupational risk assessment, the paper underlines the employer's responsibility to ensure a safe working environment, which promotes the well-being of employees and contributes to the sustainable development of the company. This approach not only protects the company's human resources, but also contributes to the long-term success of the company under investigation.

Key words: Photovoltaic panels, industrial robot operator, accident at work, occupational risk assessment and management, hazard mitigation.

1. INTRODUCTION

The basic step in optimizing the prevention of occupational accidents and diseases in a technical or work system is the identification and analysis of risks in that system; such an analysis allows for the prioritization of risks according to their size and the efficient allocation of resources for priority measures [1], [2].

Methods for risk assessment need to be as univocal and precise as possible to differentiate the risk level of various activities. In this light, we need to reduce the uncertainty in estimation of qualitative attributes such as “*severity*” and “*likelihood*” [3]. The quantified tool presented and applied in this work enable risk assessors to scale their appreciation of the severity of accidents and the factors that influence the occurrence of an accident scenario. This practice improves the transparency of the risk assessment process [4], [5].

Companies can also comply with nationally imposed legislative and regulatory requirements [6], [7], [8], [9].

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S.C. Altius Fotovoltaic S.R.L. from Giurgiu was established on 10-08-2001 and has as its main activity the CAEN code 2611 - *Manufacture of electronic subassemblies (modules)*. The company is part of the Bomax group which has built its own photovoltaic parks for the production of electricity and also wind farms, being the result of an investment of 8 million euros, half of which is private contribution and the other half is state aid. The construction of the factory took approximately 15 months.

The first photovoltaic panels were produced in Giurgiu in 2012. The factory had a capacity of 33 MW/year, which meant the production of 110 thousand items, and was to double its production capacity starting in 2014, being at that time the only producer of solar panels in Romania and among the few in Eastern Europe [10]. The full range of photovoltaic panels is produced, both monocrystalline and polycrystalline, and items requested by customers are designed on order. For the production of the panels, the necessary materials are imported from Taiwan and from European Union states, with only the aluminum frames being purchased from Romania, from Alprom Slatina. The technological line is state-of-the-art, semi-automatic, and the equipment is manufactured by leaders in the field from Germany, Japan, Italy and Finland [11].

Photovoltaic panels manufactured in Giurgiu comply with European standards and are guaranteed to operate for up to 30 years. The manufacture of panels consists of assembling batteries of cells mounted in series and encapsulating them in the most efficient way possible, so as to meet the operating requirements in a hostile external climatic environment, by hot-lamination of a sandwich formed by five materials placed in layers:

- glass;
- EVA (Ethylene Vinyl Acetate) film;
- series-connected cell battery;
- second layer of EVA film;
- backsheet film.

This formed assembly is framed in an aluminum frame. The performance of the laminator in the company's equipment, as well as the high-quality materials such as EVA foil (made in Spain), ensure the marketing of a high-quality product. The main suppliers of the investigated company are: Sotrafa S.A. Spain, Panasonic, Alprom Slatina and the main customers: Electricom S.A., OMV Petrom S.A, Aggreko South East Europe LLC as well as a significant number of household customers.

In developing the organizational structure, the management team must take into account that there is no ideal organization and no universally valid rules. The best organizational structure is the one that best meets the current needs of the company [12].

The organizational and personnel structure of Altius Fotovoltaic consists of 30 people including:

- i. **TESA body** which includes:
 - General Manager;
 - Technical Production Manager;
 - Economic Manager;
 - Personnel, Human Resources and Procurement Department.
- ii. **Executive staff** includes:
 - Industrial robot operator;

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- Subassembly assembler;
- Photovoltaic panel installer;
- Forklift operator, manager, etc.

The organizational structure having a dynamic character, changes are not only inevitable, but also typical. The adaptation of the structure is done according to the internal needs and the human resources that the company has. The organizational structure must be oriented on key activities to obtain key results.

2. DESCRIPTION OF THE FACTORY AND TECHNICAL EQUIPMENT

Within Altius Fotovoltaic LLC Giurgiu, the work process aims to operate with industrial robots, assemble subassemblies for the manufacture of photovoltaic panels. The factory is arranged in an industrial hall with a total area of 2500 sq m, having a height of 7 meters (figure 1). The construction is metallic consisting of truss beams and sandwich panels. The roof is built of sandwich panels. On the east and west sides of the hall, double-glazed windows are installed through which natural light enters the hall.



Fig.1. Industrial hall for the manufacture of photovoltaic panels: overview

Personnel access to the hall is on the north side of the building directly from the company yard. The access routes from the factory yard and inside the production hall are concreted, properly marked and comply with the regulations in force. The floors of the hall are concreted. The access road to the company is paved.

The lighting is provided at night with 2x56 W lighting fixtures placed in sufficient number (55 pieces), and during the day it is mixed (natural and artificial). The microclimate can be ensured, both in winter and summer, with the help of YORK type air conditioning installations (2 pieces). In the case of periods with high temperatures, the staff benefits from mineral water or reduced working hours, depending on the decision of the company management.

The manufacture of panels consists of assembling batteries of cells mounted in series and encapsulating them in the most efficient way possible, so as to meet the operating requirements in a hostile external climatic environment, by hot-lamination of a sandwich formed by five materials placed in layers. This formed assembly is framed in an aluminum frame (figure 2).



Fig.2. Manufacturing of photovoltaic panels: execution details and overview

The technological line is state-of-the-art and consists of the following production means:

a. *EVA/TPT sheet cutting and laying machine* (Figure 3): used for automatic cutting and stretching of the second EVA film and backsheet in the solar panel production line.



Fig.3. EVA/TPT sheet cutting and laying machine

b. *BURKLE type laminator* (figure 4)



Fig.4. BURKLE type laminator

The laminator is one of the productions means that is of particular importance in ensuring the quality of photovoltaic panels. It consists of several modules:

- *loading module* where the worker loads the materials for lamination via a belt conveyor;

- *vacuuming and pre-lamination* – seals the layers via the vacuum function to remove air. The product is then pre-laminated quickly and efficiently by thermal transfer;
- *hot press for final lamination* – completes the lamination started in the previous module. Also in this step, fast lamination and the best possible efficiency are achieved by heat transfer;
- *cold press* is used for controlled cooling of the laminated product. Possible product defects that may occur during cooling are prevented by the flat press and ensure reliable and consistent production quality
- Batch separation - similar to line loading, a final unloading bin is installed downstream of the cold press. The bin takes the entire batch of modules and separates them for the next belt conveyor, which transfers the products to downstream production processes (Figure 5).



Fig.5. Batch separation downstream of cold pressing

c. ENDEAS solar simulator (figure 6): it is used in the testing process of photovoltaic panels. The module is placed, the cables are connected and in a few seconds, the system provides comprehensive performance information.



Fig.6. ENDEAS solar simulator

3. ANALYSIS AND PRIORITIZATION OF RISKS FOR THE WORKPLACE “PHOTOVOLTAIC PANELS INSTALLER”

3.1. Description of the technological process

The work process aims to design, build and put into operation solar photovoltaic systems for individuals or legal entities with whom the company has collaborative relationships (figure 7).



Fig.7. Construction and commissioning of solar photovoltaic systems

3.2. The component elements of the evaluated work system

a. Means of production

- tool kit;
- photovoltaic panels;
- company car;
- portable impact drill;
- angle grinder (flex);
- glue gun;
- PVC pipe;
- electrical conductors;
- telecom signal transmission equipment;
- solder;
- pickling paste;
- T.S.L. locksmith kit;
- measuring and control equipment (ammeter, voltmeter);
- flashlight;
- portable ladder.

b. The workload:

- carries out electrical installations at the company's beneficiaries using production means (tool kits, angle grinder, portable drill, chainsaw, etc.) and the individual protective equipment provided;
- periodically checks fuses in the electrical panel and their calibration;
- checks the connections of technical equipment to the grounding installation;
- checks the continuity of the connection of devices to the grounding sockets;
- ensures the proper functioning of the lighting;
- carries out maintenance and repair work on electrical installations, within the limits of the service competence;
- complies with occupational safety regulations relating to the activity they carry out;
- presents themselves annually to the professional examination, occupational safety and emergency situations;
- is responsible for the proper functioning of the electrical installations within the company;
- participates in the execution of all overhaul and repair work on electrical technical equipment carried out by the company's staff or third parties;

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- is responsible for the quality of the work he directly performs.

c. Work environment

- the activity is carried out in a closed space, within the beneficiary units and outdoors;
 - the temperature and humidity of the air vary depending on the place of the activity and are within normal values most of the time;
 - when the activity is carried out outdoors, the temperature and humidity of the air vary depending on the atmospheric conditions;
 - the lighting of the work spaces is mixed - natural lighting, supplemented by artificial lighting. For intervention and repair sites where the lighting is insufficient, the installer uses a flashlight.
 - the noise level in some periods of the day is high due to the operation of the drill, chainsaw or angle grinder;
 - part of the working time is carried out in the passenger compartment of the car, when traveling in the interest of the service.

Based on the application of the INCDPM Bucharest risk assessment method [13], [14], [15], [16] and using the notations with the meanings explained in table 1, the results summarized in the “Photovoltaic panel installer” job evaluation sheet were obtained, in accordance with table 2.

Table 1. Meaning of acronyms in the risk assessment sheet

Acronym	Meaning	Acronym	Meaning
WSC	Work System Component	BFR	Biological risk factors
IRF	Identified Risk Factors	FFR	Physical risk factors
RF	Risk Factor	IC	Inappropriate content
MP	Means of Production	PO	Physical overexertion
WE	Work Environment	Ps.O	Psychical overexertion
WT	Work Task	WA	Wrong actions
HF	Human Factor	O	Omissions
MFR	Mechanical risk factors	MFC	Maximum foreseeable consequence
TFR	Thermal risk factors	S	Severity
EFR	Electrical risk factors	L	Likelihood
CFR	Chemical risk factors	PRL	Partial risk level
D	Death	INV	Invalidity
LTI	Lost time injury		

Table 2. Job evaluation sheet "Photovoltaic panel installer"

Altius Photovoltaic LLC	JOB EVALUATION SHEET	Exposed persons=7
		Exposure length =8 h/day
<i>Evaluation team:</i> Evaluator, Installer, Occupational		
Job : Photovoltaic panel installer		

			Physician, OHS Professional			
WSC	IFR	The specific form of risk factors manifestation	MFC	S	L	PR L
MP	MFR	1. Moving machine parts - flex disc, power drill - catching overall sleeves, catching, cutting upper limbs - cut or crushed wounds on the upper, lower limbs ;	INV II	5	3	4
		2. Grabbing or pulling hands or clothing items (sleeves, ties, scarves, etc.) by power tools being worked with, transmissions through fan/water pump belts, timing belts - cuts or puncture wounds to the hands.	D	7	1	3
		3. Self-locking of the steering mechanism or braking system while driving;	D	7	1	3
		4. Hit by means of motor transport and/or railway, while traveling during and on the normal route between home and workplace or between work points;	D	7	1	3
		5. Free fall of objects from a height (manipulated objects, insulators, tools, branches, etc) ;	D	7	1	3
		6. Projection of bodies or particles when working with power tools (drill, flex), (breaking masonry elements when working with a hammer, chisel, etc.) - eye diseases, facial diseases;	INV III	4	3	4
		7. Cuts and/or puncture wounds to the upper limbs, contact with dangerous surfaces (conductor ends, surfaces with burrs, tools, etc);	LTI 3-45	2	5	3
		8. Crushing of hands, fingers – when handling tools (hammer, chisel, wrench, screwdriver, screwdriver) – crush wounds ;	LTI 3-45	2	5	3
	TFR	9. Accidental direct contact with overheated surfaces in defective situations, recently processed metal surfaces, etc. - thermal burns;	LTI 3-45	2	3	2
		10. High temperature of some surfaces, accidentally touched during inspections and repairs (exhaust system galleries, engine block, etc.) - thermal burn ;	LTI 3-45	2	3	2
		11. Direct contact of the epidermis with cold metal surfaces when working outdoors in the cold season - frostbite, thermal discomfort;	ITM 3-45 ZILE	2	3	2
		12. Thermal burns caused by starting fires;	LTI 3-45	3	3	3
	EFR	13. Electrocution by direct contact in the event of performing work without removing the installation from voltage or due to damaged conductors;	D	7	2	4
		14. Electrocution by indirect contact due to lack of grounding or inadequate grounding;	D	7	1	3
	CFR	15. Flammable substances – fuels, oils, greases, etc;	D	7	1	3

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	BFR	16. Worker becoming ill through contact with the COVID 19 virus or other viruses;	D	7	1	3
WE	FFR	17. Exposure to extreme temperatures - high or low air temperature depending on the season - when performing work outdoors - frostbite, respiratory diseases ;	LTI 3-45	2	5	3
		18. Air currents – when working outdoors – rheumatic diseases, respiratory diseases;	LTI 3-45	2	4	2
		19. Low and/or unevenly distributed lighting level when performing interior electrical installation - eye disorders.	LTI 3-45	2	2	2
		20. Natural disasters - earthquake, blizzard, storm, falling trees ;	D	7	1	3
	CFR	21. Inhalation of smoke, in the event of a fire or toxic gases breaking through certain insulations (epoxy resins, PVC, etc.) followed by combustion with or without flame - poisoning, respiratory diseases;	LTI 45- 180	3	3	3
WT	IC	22. Suspension of the vehicle, in case of flat tires, using improvised and/or unapproved means ;	D	7	1	3
		23. Storage of materials with which the work is to be carried out, on access routes - dislocations, fractures;	LTI 3-45	2	5	3
	PO	24. Back and lumbar disorders – forced positions when installing panels, fixed position when driving long distances in the company car ;	LTI 3-45	2	4	2
	Ps. O	25. Stress caused by working at height, the possibility of falling - neuropsychiatric disorders;	LTI 3-45	2	6	3
HF	WA	26. Performing unforeseen operations in the work task;	D	7	1	3
		27. Driving under the influence of alcohol, drugs or in an advanced state of fatigue;	D	7	1	3
		28. Performing maneuvers not permitted by the legislation regulating traffic on public roads: overtaking, turning, in areas where these maneuvers are prohibited;	D	7	2	4
		29. Driving without fastening the seat belt	D	7	1	3
		30. Performing maneuvers without ensuring visibility (especially when reversing);	D	7	1	3
		31. Driving with faults in the steering mechanism, electrical system, braking system;	D	7	2	4
		32. Failure to adapt speed to traffic and weather conditions;	D	7	2	4
		33. Exceeding the maximum number of persons allowed, the maximum permitted load;.	D	7	1	3
		34. Stopping the engine on a slope and putting the gear lever in neutral (when descending);	D	7	1	3
		35. Engaging in conversations with passengers or using a mobile phone without a hands-free system;	D	7	1	3
		36. Putting a faulty installation or power tool (drill, flex, etc.) under voltage;	D	7	1	3

O	37. Working with faulty tools and appliances (voltage indicators, measuring devices, patents, fuses);	LTI 3-45	2	5	3
	38. Execution of improvisations - conductors of inappropriate section, damaged insulation - placed on traffic routes;	D	7	1	3
	39. Traveling, standing in hazardous areas - on access roads, in working area of lifting equipment, etc;	D	7	1	3
	40. Falling from the same level due to imbalance, slipping, tripping, dislocations, fractures;	LTI 3-45	2	5	3
	41. Fall from height - from ladders, poles or when working at heights;	D	7	1	3
	42. Failure to use personal protective equipment and other protective equipment provided (safety helmet, overalls, electrically insulating boots and gloves, safety belt, etc)	D	7	2	4
	43. Failure to comply with the ITP technical inspection schedule of the vehicle.	D	7	1	3

The overall risk level of the workplace is:

$$N_{rg} = (7(4 \times 4) + 30(3 \times 3) + 6(2 \times 2)) / (7 \times 4 + 30 \times 3 + 6 \times 2) = 3.15$$

Figure 8 represents the so-called "risk landscape", in this case the histogram showing all the identified risks and the corresponding partial risk levels, and table 3 summarizes the main prevention and protection measures intended to minimize the risks considered to be included - following the assessment - in the field of intolerable risks.

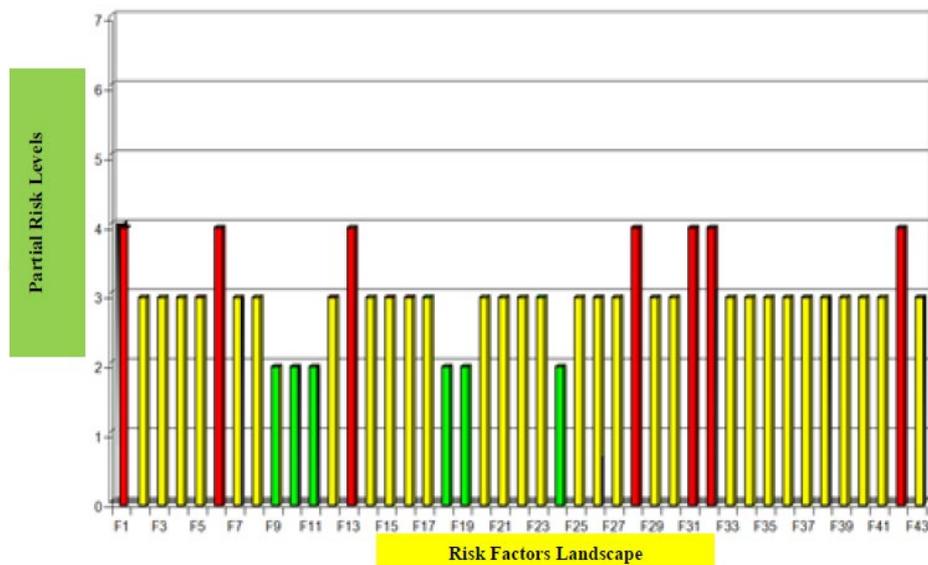


Fig.8. Histogram of partial risk levels associated with individual identified risks

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3.3. Proposed measures sheet: Workplace: "Photovoltaic panel installer"

Table 3. Proposed measures to minimize the identified risks

Risk factors	Risk level	Proposed measures
Moving machine parts - flex disc, chainsaw chain, power drill - catching overall sleeves, catching, cutting upper limbs - cut or crushed wounds to the upper and lower limbs	4	<p>Organizational measures: Training workers on the risks they are exposed to when working with machines that have moving parts, Verifying the existence of protective guards; Verifying compliance with their own instructions. Presenting first aid measures in case of injuries.</p>
Projection of bodies or particles when working with power tools (drill, flex, breaking masonry elements when working with a hammer, chisel, etc.) - eye diseases, facial diseases	4	<p>Technical measures: Providing protective glasses Organizational measures: Mandatory use of protective glasses when working with a grinder, chainsaw or electric drill Training personnel on the risks they are exposed to by not using protective equipment when working with a grinder or electric drill</p>
Electrocution by direct contact in the event of performing work without removing the installation from voltage or due to damaged conductors, faulty switches, sockets, plugs	4	<p>Technical measures: Prohibition of putting faulty equipment into operation through safety indicator of prohibition and electrical separation Equipping with appropriate PPE Organizational measures: Verification of the use of PPE HSE training. Presentation of first aid measures in case of electric shock</p>
Performing maneuvers not permitted by the legislation regulating traffic on public roads: overtaking, turning, in areas where these maneuvers are prohibited	4	<p>Organizational measures: OHS training, processing of own OHS instructions, of the prevention and protection plan, of the provisions of the Highway Code and raising workers' awareness of the risks they are exposed to by not respecting the provisions contained in these documents</p>
Driving with faults in the steering mechanism, electrical system, braking system	4	<p>Organizational measures: OHS training, processing of own OHS instructions, of the prevention and protection plan, of the provisions of the Highway Code and raising workers' awareness of the risks they are exposed to by not respecting the provisions contained in these documents</p>
Failure to use personal protective equipment and other protective equipment provided (safety helmet, overalls,	4	<p>Technical measures: Providing personal protective equipment (electrically insulating boots and gloves, boots, overalls, safety glasses, safety helmet) and other necessary protective equipment</p>

electrically insulating boots and gloves, etc.)		Organizational measures: HSE training Checking the wearing of personal protective equipment and other protective equipment Training staff on the risks they are exposed to by not using the protective equipment provided
Failure to adapt speed to traffic and weather conditions	4	Organizational measures: OHS training, processing of own OHS instructions, of the prevention and protection plan, of the provisions of the Highway Code and raising workers' awareness of the risks they are exposed to by not respecting the provisions contained in these documents
Grasping, driving hands or clothing items (sleeves, ties, scarves, etc.) by fan/water pump belt transmissions, timing belt	3	Organizational measures: Health and safety training Presentation of first aid measures in case of accident
Self-locking of the steering mechanism or braking system while driving	3	Organizational measures: Compliance with the deadlines for carrying out the periodic technical inspection of the vehicle (ITP)
Hit by means of motor transport and/or railway, while traveling during and on the normal route between home and workplace or between work points	3	Organizational measures: Training on the risks and the need to respect traffic rules when traveling on public roads.
Free fall of objects from height (insulators, tools, branches, tiles, trees during deforestation, etc)	3	Technical measures: Equipped with PPE (head protection helmet) Organizational measures: HSE training. Verification of PPE use.
Cuts and/or puncture wounds to the upper limbs, contact with hazardous surfaces (conductor ends, burr surfaces, tools)	3	Organizational measures: OHS training on handling and working with cutting surfaces
Thermal burns caused by starting fires	3	Organizational measures: OHS and SU training Presentation of first aid measures in case of burns.
Fall from height - from a ladder or when working at heights	3	Organizational measures: Health and safety training Carrying out periodic medical check-ups Technical measures: Equipped with a quality certified ladder.
Failure to comply with the ITP technical inspection schedule of the vehicle	3	Organizational measures: OHS training Respect for the due date of the Periodic Technical Inspection ITP. Processing the provisions of the Road Regulations

3.4. Interpretation of assessment results

The global risk level calculated for the job "photovoltaic panel installer" is equal to 3.15, a value that places it in the category of jobs with a medium risk level, not exceeding the maximum acceptable limit (3.5). The result is supported by the "Assessment Sheet", from which it is observed that out of the total of 43 risk factors identified, only 7 exceed, as a partial risk level, the value 3. In order to reduce or eliminate the 7 risk factors that are in the unacceptable range, it is necessary to implement the generic measures included in the document entitled "Proposed measures sheet". Regarding the distribution of risk factors by generating sources, the situation is as shown in the diagram represented in figure 9, in particular:

- 37%, factors specific to the means of production;
- 12%, factors specific to the work environment;
- 9%, factors specific to the work task;
- 42%, factors specific to the human factor.

From the analysis of the Evaluation Sheet, it is found that 64% of the identified risk factors can have irreversible consequences on the human factor (death or disability), so that the workplace can be classified among those with a particular risk of injury.

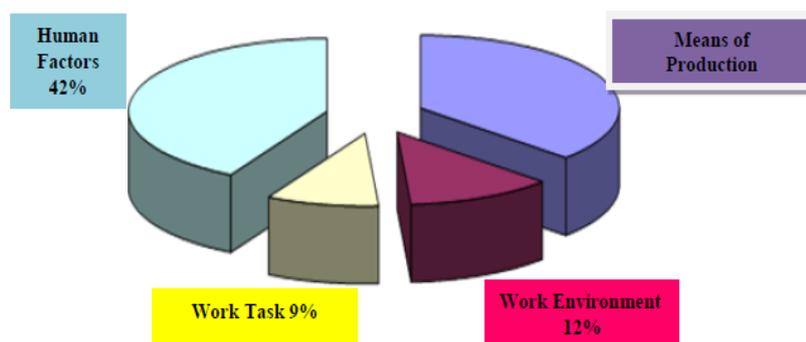


Fig 9. Distribution of identified risk factors by generating source for the job position: "Photovoltaic Panel Installer," with an overall risk level of 3.15.

4. CONCLUSIONS

This research paper targeted a specific aspect of occupational risk management in a Romanian company manufacturing and installing solar photovoltaic panels, namely the assessment, in accordance with the provisions of national legislation in the field, harmonized with the *acquis communautaire* of the European Union.

To support employers in fulfilling their legal obligations in the field of occupational risk assessment, there are currently many assessment methods that are used, but for the purpose of carrying out the case study, the I.N.C.D.P.M. method of "*Assessment of occupational accident and illness risks at work (workplace)*" was applied, a useful tool in identifying and ranking hazards - and associated risks, which retains its usefulness and purpose as long as it is applied with discernment, attention and by using a balanced and homogeneous balance in the phase of allocating the probability

classes and those of severity associated with the risk factors identified by the members of the assessment team.

The research was based on the analysis of each work station in the field and on the primary documents regarding technology and human resources provided by S.C. Altius Fotovoltaic S.R.L., namely: the content of the work processes for the analyzed places, job descriptions, determination bulletins; statistics of work accidents in the last 10 years as well as the own observations made by the members of the analysis team during the documentation visits, monitoring and tracking of the specific activity for each workplace/work station among those investigated.

The results of the occupational risk assessment by applying the method in the manner presented are presented in the "Job Assessment Sheet" and the "Proposed Measures Sheet" for each analyzed workplace. The list of evaluated workplaces is given in Table 4.

Table 4. List of evaluated jobs from the investigated company

Workplace No.	No. sheet	Workplace	Overall risk level
1	F1	Industrial robot operator	2.89
2	F2	Photovoltaic panel installer	3.15
3	F3	Forklift operator	3.00

The overall risk level for the 3 jobs is:

$$N_{gs} = \frac{\sum_{i=1}^3 Nrg_i \times Nrg_i}{\sum_{i=1}^3 Nrg_i} = \frac{27,12}{9,02} = 3,00$$

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

Table 5. Ranking of investigated workplaces according to the calculated risk level

Workplace No.	No. sheet	Workplace	Overall risk level
1	F3	Photovoltaic panel installer	3,15
2	F2	Forklift operator	3,00
3	F1	Industrial robot operator	2,89

According to the hierarchy, it is found that all workplaces have a global risk level below the allowed limit (3.5), falling into the category of those with a low to medium risk level. The aggregate global risk level of the company, $N_{gs} = 3.00$, confirms this classification, reflecting - to a large extent - the efficiency of the prevention and protection measures implemented within the company. Therefore, S.C. Altius Fotovoltaic SRL Giurgiu falls into the category of companies with a medium risk level.

It can be said that the assessment of occupational accident and disease risks represents a necessary and useful tool for fulfilling the established duties, for the management of Altius Fotovoltaic SRL and for the personnel with duties in the field of occupational safety and health, because it allows the identification of all risk factors,

establishing the size of the risks, which is a mandatory stage for the development of own occupational safety norms and instructions, for the generation of own personnel training materials in the field of occupational safety and health. On this basis, it becomes possible to substantiate a program of awareness of all stakeholders regarding the establishment, development and culmination of a positive culture of risk management, in an initial "top - down" approach, with the consequence of the germination of a participatory approach, oriented "bottom - up" that will complete a proactive organizational security culture, in the spirit of the principles of the ISO 31000 standard.

REFERENCES

- [1]. **Aven T.**, *Risk assessment and risk management: review of recent advances on their foundation*. Eur J Oper Res 253(1):1–13, 2016.
- [2]. **Azadeh-Fard N., Schuh A., Rashedi E., Camelio J.A.**, *Risk assessment of occupational injuries using accident severity grade*. Saf Sci 76:160–167, 2015.
- [3]. **Băbuț G.B., Moraru R.I.**, *Critical analysis and ways to improve the I.N.C.D.P.M. Bucharest for the assessment of the risks of accidents and occupational diseases*, "Quality - access to success", vol. 14, no. 137, pp. 55-66, 2013.
- [4]. **Ispășoiu A., Moraru R.I., Popescu-Stelea M., Băbuț G.B.**, *Study on the potential of artificial intelligence application in industrial ergonomics performance improvement*, Acta Technica Napocensis - Series: Applied Mathematics, Mechanics and Engineering, [S.l.], v. 64, n. 1-S1, Pages: 45-54 , feb. 2021.
- [5]. **Joy J., Griffiths D.**, *National minerals industry safety and health risk assessment guideline*, version 3, March 2008, MCA and MISHC, Australia, www.planning.nsw.gov.au
- [6]. **Moraru R.I., Băbuț G.B., Cioca L.I.**, Rationale and Criteria Development for Risk Assessment Tool Selection in Work Environments, *Environmental Engineering and Management Journal*, Vol. 13, No. 6, pp.1371 – 1376, 2014.
- [7]. **Stanton N.A., Harvey C.**, *Beyond human error taxonomies in assessment of risk in sociotechnical systems: a new paradigm with the EAST 'broken-links' approach*. Ergonomics 60(2):221–233, 2017.
- [8]. *** **Labour Inspection**, *Verifying how employers comply with legal requirements for professional risk assessment. Guidance for inspectors* (in Romanian), Labour Inspection, Bucharest, Romania, 2015.
- [9]. *** **Romanian Parliament**, Law no. 319 regarding occupational safety and health (in Romanian), *The Official Journal of Romania*, part I, no. 646/26.07.2006, Bucharest, Romania.
- [10]. *** **European Commission**, *Guidance on risk assessment at work* (Directive 89/391/EEC), European Commission, Directorate General V Employment, Industrial Relations and Social Affairs, Office for Official Publications of the European Communities, Luxembourg, 1996.
- [11]. *** **Romanian Government**, Government Decision no. 1048 regarding the minimum safety and health requirements for the use by workers of personal protective equipment at the workplace (in Romanian), *The Official Journal of Romania*, part I, no. 722/23.08.2006, Bucharest, Romania, 2006a.
- [12]. *** **Romanian Government**, Government Decision no. 1425 for approval of Methodological Norms for applying occupational safety and health Law no. 319/2006 (in Romanian), *The Official Journal of Romania*, part I, no. 882/30.10.2006, Bucharest, Romania, 2006b .

[13]. *** **Romanian Government**, Government Decision no. 1029 regarding the conditions for placing machines on the market (in Romanian), *The Official Journal of Romania*, Part I, no. 674/30.09.2008.

[14]. *** **Romanian Government**, Government Decision no. 517 for amending and supplementing Government Decision no. 1029/2008 regarding the conditions for placing machines on the market (in Romanian), *The Official Journal of Romania*, Part I, no. 373/27.05.2011.

[15]. *** **Romanian Government**, Government Decision no. 191 for the approval of the National Strategy on Safety and Health at Work for the period 2018-2020 (in Romanian), *The Official Journal of Romania*, Part I, no. 331/16.04.2018.

[16]. *** **HSE**, *The health and safety toolbox: How to reduce risks at work*, HSG268, Health and Safety Executive (HSE), Bootle, Great Britain, 2014, (available at: <http://www.hse.gov.uk/pubns/priced/hsg268.pdf>).