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HEALTH AND SAFETY RISK ASSESSMENT FOR THREE REPRESENTATIVE WORKSTATIONS FROM PAROSENI THERMO-ELECTRIC POWER PLANT

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Abstract: The results obtained regarding the assessment of occupational injury and illness risks for three representative workplaces within a thermo-electric power plant are presented, following the application of a nationally recognized method. Based on the description of the investigated workplaces, the identification of specific risks, the allocation of severity and probability classes, the calculation of partial and global risk levels, the ranking of risks and the establishment of intervention priorities were carried out. On this basis, prevention and protection measures intended to be implemented in order to minimize occupational risks in a pragmatic, feasible and realistic manner were proposed.

Key words: thermo-electric power plant, risk of injury and occupational disease, probability, severity, prevention and protection measures.

1. INTRODUCTION

In specialized terminology, human safety in the work process is considered as that state of the work system in which the possibility of occupational injury and illness is excluded. In common language, safety is defined as the fact of being safe from any hazard, and risk - the possibility of getting into hazard [1], [13]. If we consider the usual meanings of these terms, we can define safety as the state of the work system in which the risk of injury and illness is zero. Therefore, safety and risk are two abstract, opposite concepts that are mutually exclusive [2], [14].

In reality, due to the features of any work system, such absolute states cannot be achieved [3], [16]. There is no system in which the potential risk of injury or illness is completely excluded; there is always a "*residual*" risk, if only due to the unpredictability of human action. If corrective interventions are not made along the way, this residual risk increases as elements of the work system degrade through "*aging*". Consequently, the systems can be characterized by "safety levels", respectively "risk levels", as quantitative indicators of the safety and risk states respectively [4], [5].

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In this context, in practice a minimum risk limit must be admitted, i.e. a risk level different from zero, but small enough to consider that the system is safe, as well as a maximum risk limit, which is equivalent to a such a low level of safety that the operation of the system is no longer allowed [6], [7], [23]. Risk has been defined in the specialized literature in the field of work safety by the probability with which, in a work process, an accident or a professional illness occurs, with a certain frequency and severity of the consequences [8], [17].

Indeed, if we admit a certain risk, we can represent it, depending on the severity and the probability of the consequences, through the surface of a rectangle, developed vertically; it follows that the same surface can also be expressed by a square or by a rectangle extended horizontally. In all three cases the risk is equally high. Consequently, we can assign different gravity - probability couples, the same level of risk.

If we join the three rectangles through a line drawn through the vertices that are not on the coordinate axes, we obtain a curve with the appearance of a hyperbola, which describes the connection between the two variables: gravity - probability. In order to represent the risk as a function of severity and probability, such a curve is defined as a "*risk acceptability curve*" [9], [15].

This curve allows the differentiation between acceptable and unacceptable risk. Thus, the risk of occurrence of an event A, with serious consequences, but very low frequency, located below the acceptability curve, is considered acceptable, and the risk of event B, with less serious consequences, but with a higher probability of occurrence, of whose coordinates lie above the curve, is unacceptable. For example, in the case of a nuclear power plant, such measures are taken that the risk of a nuclear event - be it the risk of event A - is characterized by an extreme seriousness of the consequences, but an extremely low probability of occurrence [18], [20].

Due to the very low frequency of occurrence, the activity is considered safe and the risk accepted by society. Conversely, if for the risk of event B we take as an example the road accident caused by the activity of a driver, although this type of event causes less serious consequences than a nuclear accident, the probability of occurrence is so high (very high frequency) that the place of the driver's work is considered unsafe (unacceptable risk) [19], [22]. Any safety study aims to establish acceptable risks. Such a treatment of risk raises two problems:

- how to establish the coordinates of the risk: the gravity-probability couple;
- which risk coordinates will be chosen to delimit the areas of acceptability from those of unacceptability.

In order to solve them, the premise from which the development of the applied evaluation method started was the risk - risk factor relationship. The existence of risk in a work system is due to the presence of occupational injury and disease risk factors [21]. Therefore, the elements with which the risk can be characterized, so its coordinates can be determined, are actually the probability with which the action of a risk factor can lead to an accident and the severity of the consequence of the action of the risk factor on the victim. Risk assessment for the safety and health of workers is a legal obligation for any organization [10-12].

2. MATERIAL AND METHOD

2.1. General presentation of the Paroșeni Electrocentrale Branch

The activity profile of the organization is the production and emission in the National Energy System of electricity, installed power 150 MWh. The Paroşeni Electrocentrale branch was built at the beginning of the 50s, starting from a project of Russian origin, being the first coal-fired power plant in our country. The electricity and thermal energy production plant in the municipality of Vulcan was designed to supply the entire Valea Jiului region with electricity and thermal energy, as well as the mining industry in the six localities of the area. The modernization of the Paroşeni Power Plant was carried out by a consortium formed by the Japanese companies Itochu, Hitachi and Toshiba. The project included the refurbishment of a group of 150 megawatts and 150 gigacalories/hour.

Generically named "*Group IV*" of S.E Paroseni, it was put into operation in 2007 and represents the largest investment in the thermal energy system since 1989 and until now. The Paroseni power plant is located in the central part of Romania, in the so-called "*Jiu river valley*", which connects the south (Oltenia region) with the center of Romania (Transylvania). The Paroseni power plant is located on the lower terrace on the right bank of the West Jiului, "*at the mouth of the mine*" in the center of the Petroşani depression, between the towns of Vulcan and Lupeni. The road access to the plant site is made from DN 66 A Petrosani-Lupeni, and the railway connection is made from Vulcan Station via the independent railway line of the plant (Fig.1).

Fig.1. Location of the Paroşeni Power Plant

Access to S.E. Paroşeni is reached from the national road "*DN - 66A*", practicable all year round. The access of intervention vehicles to the objective is achieved through the main gate and a secondary entrance (gate no. 2). The internal access roads are 90% paved and the rest are paved and are accessible to emergency vehicles all year round. During bad weather, the roads leading to the coal stacks and coal unloading stations no. 1 and 2 are more difficult to access for emergency vehicles. The coal is brought to the plant by normal railway on the route "Vulcan station - Paroşeni sorting - coal stacks S.E. parishioners".

Coal is provided by a number of mines located approx. 5-15 km away from the plant. Its transport is done by rail. Coal unloading is done from wagons either in the coal stacks or directly in the bunkers of the coal unloading station (Fig.2).

Fig. 2. The coal unloading station

The solid fuel storage consists of two equal coal stacks with a total capacity of 60,000 tons. The coal stacks are slightly elevated above the level of the surrounding land and have been provided with water drains. BAT technologies (the best available techniques) are applied to the entire fuel flow of the plant: unloading, sorting-crushing, storage-retrieval, transport and supply of bunkers arranged on two distinct circuits (reserve in machinery 100%) so that corroborated with the nominal flow rate and the reserve stock, it is possible to ensure the coal supply continuously and at the parameters required for the boilers in operation.

With the help of the belt circuit, the coal reaches the bunkers of the mills. In coal mills, coal dust is obtained which reaches the coal burners through the air-dust pipes. Physico-chemical characteristics of the type of coal used (project data):

- total humidity: 11.2 - 6.0 % (10.7 % guarantee value);
- ash: 46-33.7 % (38.0 % guarantee value);
- lower calorific value: 3300-4510 kcal/kg (3916 % guarantee value).

The natural gas is taken from the national methane gas distribution network (SNGN ROMGAZ SA Mediaş), by means of a regulation and measurement station, located in the vicinity, through a pipe with nominal diameter Dn 500 mm.

The measurement regulation station has the role of filtration, pressure regulation and measurement of the gas used in the plant (Fig.3).

Fig.3. The measurement regulation station

- maximum pressure after SRM: 0.5 bar;
- nominal pressure after SRM: 0.35 bar;
- minimum breakdown pressure: 0.2 bar.

Physico-chemical characteristics of natural gas for starting and sustaining, Pci = 8050 ÷ 9500 kcal /Nmc.

The amount of gas consumed annually is 5,500 thousand m3, at an average calorific value of 8330 l/m3. Cooling water (technological water): the cooling water supply source (on the hydrotechnical circuit) is the Jiul de Vest river through a mobile dam equipped with 5 weirs, located 1.5 km upstream from the plant. About 200 m downstream from the water intake there is a decanter with a flow rate of 54,000 mc/h, provided with 2 settling chambers (Fig.4).

Fig.4. Baleia dam

The water is passed through a sanitiser and is transported by gravity to the plant through a reinforced concrete channel with two compartments. The plant can operate in open, mixed and closed circuit. The indoor cooling circuit is composed of hot and cold water channels and pipes, cooling water pump station and cooling towers, respectively:

- 5 cooling towers with countercurrent natural draft, Hyperbolic type, of which 3 in operation and 2 withdrawn from operation, capacity 10,000 m^3/h each (Fig.5);

Fig.5. Cooling towers

- 6 recirculation pumps for mixed or closed circuit;
- 2 pcs (1 and 2) P=250 Kw and Q= 4,000 m^3/h;
- 4 pcs (3-6) P= 1100 KW and Q = 12,000 m^3/h.

The evacuation of the water from the cooling circuit is done in the Jiul de Vest river, through an open channel. The water requirement for the plant is:

- open circuit – 29,920 m^3/h;

- mixed circuit – 13,160 m^3/h;
- closed circuit – 1,160 m^3/h.

Water consumption in West Jiu in 2013 was 19,981 thousand cubic meters. The water flow is necessary for the following installations:

- turbine condensate installation;
- cooling installation;
- slag and ash evacuation system.

2.2. The applied method for assessing the accidents and occupational diseases risks

The method developed within the I.N.C.D.P.M. Bucharest aims to quantitatively determine the level of risk for a workplace, sector, section or enterprise, based on the systemic analysis and assessment of occupational injury and disease risks. The essence of the method consists in the identification of all risk factors in the analyzed system (workplace) based on predetermined checklists and the quantification of the size of the risk based on the combination of severity and frequency of the maximum foreseeable consequence. The method can be used both in the conception and design phase of jobs, as well as in the exploitation phase. However, its application requires complex teams made up of people specialized both in work safety and in the analyzed technology (evaluators + technologists). In the first situation, the method is a useful and necessary tool for designers in order to integrate the principles and measures of work safety in the conception and design of work systems. In the exploitation phase, the method is useful to the personnel from the labor protection departments of enterprises for the fulfillment of the following attributions:

- the analysis on a scientific basis of the state of labor security at each workplace;
- rigorous substantiation of prevention programs.

The method includes the following ***mandatory steps***:

1. *defining the system to be analyzed (job);*
2. *identification of risk factors in the system;*
3. *assessment of occupational injury and illness risks;*
4. *the ranking of risks and the establishment of prevention priorities;*
5. *proposing preventive measures*.

The steps necessary for the assessment of work security in a system, described previously, are carried out using the following ***work tools***:

a. *List of identification of risk factors;*
b. *List of possible consequences of the action of risk factors on the human body;*
c. *Rating scale of severity and probability of consequences;*
d. *The risk assessment grid;*
e. *The classification scale of the risk levels, respectively of the security levels;*
f. *Job sheet - centralized document;*

g. *List of proposed measures.*

The global risk level (N_r) at the workplace is calculated as a weighted average of the risk levels established for the identified risk factors. In order for the obtained result to reflect reality as accurately as possible, the rank of the risk factor is used as a weighting element, which is equal to the risk level.

In this way, the factor with the highest level of risk will also have the highest rank. This eliminates the possibility that the compensation effect between extremes, which any statistical average implies, masks the presence of the factor with the maximum level of risk. The formula for calculating the global risk level is as follows:

$$N_r = \frac{\sum_{i=1}^{n} r_i \cdot R_i}{\sum_{i=1}^{n} r_i} \qquad (1)$$

where:

N_r is the overall level of risk in the workplace;

r_i - "i" risk factor rank;

R_i - risk level for risk factor "i";

n - the number of risk factors identified at the workplace.

The application of the method ends with the drafting of the analysis report. This is an informal instrument that must contain, clearly and succinctly, the following:

- the manner of carrying out the analysis;
- the persons involved;
- the results of the assessment, respectively job sheets with risk levels;
- interpretation of the evaluation results;
- prevention measures sheets.

In order for the application of the method to lead to the most relevant results, the first condition is that the system to be analyzed is a workplace, well defined in terms of its purpose and elements. In this way, the number and type of potential interrelationships to be investigated and implicitly the risk factors to be considered are limited.

A particularly important condition is the existence of a complex and multidisciplinary evaluation team, which includes occupational safety specialists, designers, technologists, ergonomists, physicians specialized in occupational medicine, etc., corresponding to the varied nature of the elements of work systems, but also to risk factors. The team leader must be the occupational safety specialist, whose main role will be to harmonize the points of view of the other evaluators, in the sense of subordinating and integrating the criteria used by each of them to the goal pursued by the analysis: the evaluation of occupational safety.

3. ASSESSMENT OF RISKS FOR THE SAFETY AND HEALTH OF WORKERS WITHIN THE FRAMEWORK OF C.E.T. PAROSENI: EARTH – COAL MOVER MACHINIST

3.1. The work process/task

The MCB bucket wheel combined machine is intended for operation in the coal depot at S.E. Paroşeni, being able to perform the following distinct operations:

- heap stacking of the coal taken from the stationary belt on the ground;
- taking the coal from the dump and depositing it on the stationary belt from the ground (and from here, to the energy boilers for steam production);
- passing the entire flow of material from the stationary conveyor belt from the ground through the machine (by-passing the machine);
- picking up the material from the dump and additionally depositing it on the material flow of the stationary conveyor belt on the ground that passes through the machine (by-passing + additional depositing).

For taking or depositing (stacking) the coal, the combined machine can work from a fixed point or by translating the machine (on its track). For the safety of the attendants and the machine, to avoid accidents, the component equipment are connected in an interlocking system that ensures the stopping of the upstream or downstream equipment, as the case may be, when one of the equipment stops. For example, in stacking mode, if the reversible arm conveyor is stopped, then the intermediate conveyor, ground belt 11B and all upstream belt flow will be stopped by interlocking. Another example: in pick-up mode, if the reversible conveyor stops, then the bucket rotor will also stop.

3.2. The means/equipments of production

The combined machine with bucket wheel serves:

- in the stacking cycle - for depositing the material in the above-ground storage of the thermal power plant;
- in the pick-up cycle - for removing the material from storage.

The pick-up and stacking arm can perform a rotation movement relative to the track axis as well as a lifting-lowering movement. The coal stacking and taking operations are performed on one side of the track, along the warehouse. The power supply of the control and power devices is made by cables which, during the translational movement of the machine, are wound on the cable drums. The control cabin is located as reasonably as possible at the top of the boom, ensuring optimal visibility during operation. The operation of the machine is done in accordance with the work safety instructions of the respective work sector and the internal instructions developed by the Fuel Exploitation Section.

3.3. Working task

The earthmoving machine drivers work in 3 shifts, according to the monthly schedule, based on the schedule (shift I, II or III). They, depending on the level of authorization (ISCIR and internal), work on the various earthmoving machines in the warehouse. The combined machine is operated by at least two drivers:

- machinist handling the machine (driver of the machine);
- machinist supervision and current maintenance of the machine.

During the service, the two machinists collaborate and support each other, they can replace each other, rotate in the execution of the tasks and therefore work in approximately the same conditions. For this reason, they are exposed to the same risks of accidents and occupational diseases. During the operation of the combined machine, if necessary, the intervention of the operation, maintenance or PRAM - AMC electricians is ensured.

3.4. Work environment

The combined machine serves the external coal storage, located in the western part of the thermal power plant premises. The activity of the drivers on the combined machine takes place both in the cabin of the machine and in the open air, on the work platforms and its circulation paths. The work platforms and circulation lanes are made of corrugated sheet metal or metal gratings, to ensure a good grip when the workers who use them move or stand. However, in winter there is the possibility of snow deposition and the formation of portions of ice, and therefore there is a risk of slipping. There is work lighting and backup lighting for continuing work or evacuation. The lighting is natural during the day and artificial at night, from the headlights and projectors of the car and from the projectors on the perimeter of the warehouse. The climate in Vulcan - Paroşeni is normal temperate. The temperatures usually fall between the values "- 20 ˚C" and "+ 30 °C" and the relative humidity is a maximum of 65%.

The cab of the combined machine is heated, but in winter the operator for supervision and current maintenance (who works outdoors on the outside platforms) is exposed to low temperatures, precipitation and drafts. During hot periods, both machinists who service the machine are exposed to high temperatures. At wind speeds greater than 25 m/s, the wind protection operates and the machine disengages and stops working. Due to the motors on the machine, the carbon belts, the bucket rotor, the production of vibrations is inherent during its operation and these are transmitted to the limbs and throughout the body, from the seat, levers, floors, platforms, etc.

During operation, the swing of the machine arm, on which the bucket wheel and control cab are mounted, may occur. The noise produced during the operation of the machine does not exceed the permitted limit of 87 dB, neither in the cabin nor in the outside spaces. Because masses of coal are handled, drivers are exposed to respirable pneumoconiogenic dusts, especially when the coal is dry. To a lesser extent, because they work outdoors, they are exposed to toxic gases, vapors, aerosols from the operation of engines. It can be concluded that the outdoor coal storage is a rather aggressive workplace, which presents risks of injury and illness for the workers. Types of accidents / diseases related to the profession: mechanical trauma, cutting, slipping, penetration of foreign bodies into the eyes, burns, intoxications, electrocutions, sunstrokes, colds, rheumatic diseases, dorsolumbar diseases, etc.

A relevant extract from the risk assessment sheet is represented in table 1.

Table 1. ***The evaluation form of the analyzed workplace***

Unit: SC Hunedoara Energy Complex		**THE EVALUATION FORM OF THE ANALYZED WORKPLACE**	**Workers exposed:** 15			
Section: C.E.T Paroşeni			**Exposure length**: 8 h/shift			
Workplace: Earth-coal mover machinist			**Evaluation team**: Risk assessor, department head, occupational medicine doctor, machine operator			
Work system component	**Identified risk factors**	**The concrete form of manifestation of the risk factors (description, parameters)**	**Max. severity**	**Severity class**	**Likelihood class**	**Risk level**
a. <u>Work equipment</u>	***a1.Mechanical risk factors***	1. Functional movements of technical equipment and machine parts in motion: translating (moving) the entire machine on the CF rail, turning / raising / lowering the arm, raising / lowering the belt rider, turning bucket wheel, running belts, rollers and tape drums , strippers and plows, discharge funnels and valves, servomechanisms (hydraulic cylinders), drums for electrical cables, etc.	Death	7	3	5
		4. The overturning of the machine due to the appearance of additional loads that lead to the imbalance of the access due to improper operation in winter (additional loads due to snow, frost), operation during strong wind (with a speed greater than 25 m/sec.), the production of sudden movements, shocks in the event of malfunctions (e.g. the failure of the arm tilting servomechanism with bucket) or the appearance of additional resistances (e.g. frozen portions in the coal stack, in winter), obstacles on the machine's path, etc.	Death	7	2	4
		7. The uncontrollable swing of the machine arm and the driver's cab or sudden movement (shock), due to some obstacles in the work front (e.g. bolts, metals, wooden material), difficult working conditions in winter due to frost, non-compliance with the prescriptions in the machine's technical book.	Death	7	2	4

		13. Containers under pressure: hydraulic cylinders, hoses, solenoid valves, etc. from the arm tilting servomechanisms and the rider conveyor (30 - 160 bar).	Death	7	1	3
	a2. Thermal risk factors	15. High temperature of accidentally touched surfaces (eg: ungreased, seized bearing boxes and transmission boxes; terminal boxes and motor casings with electrical or mechanical defects).	ITM 3 - 45 days	2	3	2
	a3. Electrical risk factors	17. Electrocution by direct contact with live components of equipment or installations (e.g. accidental damage to housings or insulation).	Death	7	1	3
	a4. Chemical risk factors	19. Risk of fire due to the presence of combustible and flammable materials: coal, coal dust, rubber tape, cable insulation, oils, greases.	Invalidity degree 3	4	3	4
b. <u>Work environment</u>	***b1. Physical risk factors***	20. High air temperature in the summer, during hot periods, when it is possible to go beyond the normal limits of comfort.	ITM 3 - 45 days	2	3	2
		21. Low air temperature in winter, when working outdoors, when starting work when the cabin is not heated, when carrying out revisions or repairs.	ITM 45 - 180 days	3	4	3
		22. Drafts when working outdoors or due to leaks in the cabin.	ITM 3 - 45 days	2	4	2
		26. Insufficient exterior lighting level of the warehouse at night in some parts.	Death	7	2	4
		27. Natural calamities: lightning, strong wind, blizzard, hail, frost, earthquake.	Death	7	1	3
	b2. Chemical risk factors	28. Pneumoconiogenic dusts in suspension in the breathed air (respirable quartz dusts that can exceed the maximum permissible limit of 2 mg/m3) due to the handling of coal masses - dust released in the area of the bucket rotor, coal discharge points and due to oscillations during the movement of the belt over the rollers and the vibrations induced by the rotating aggregates .	Disability degree 3	4	3	4
	b3.	29. Dangerous animals (stray dogs) or insects (wasps, bees).	Death	7	1	3

	Biological risk factors					
c. <u>Working task</u>	***c2. Oversized / undersized task in relation to the ability of the performer***	30. Static effort exerted by the driver in the cab, for handling the machine controls.	Negligible ITM < 3 days	1	5	1
		31. Dynamic effort (high physical effort) performed by the supervising machinist for cleaning the color, platforms (dust and fallen material), cleaning stuck material on rollers, drums, beams, etc., unclogging hoppers, movements to carry out maneuvers, adjustments and supervision, maintenance works, liquidation of accidents, incidents, snow removal in winter, etc.	ITM 3 - 45 days	2	5	3
		35. Stress due to some (possible) problems at department and/or company level (e.g. relationships with colleagues and superiors, tasks and workload, work climate, job uncertainty, etc.) and own problems (health, financial problems, family problems, etc.).	ITM 45 - 180 zile	3	3	3
d. <u>Human factor</u>	***d1. Wrong actions***	36. Working under the influence of alcoholic beverages, in an advanced stage of fatigue or after taking certain medications.	Death	7	1	3
		37. Working under the influence of inappropriate conditions at the moment (stress, emotions, nervousness, depression, family or professional conflicts, voluntary effort at the moment).	Death	7	2	4
		43. Leaving the cab by the driver while the machine is operating, without stopping it, putting the controls in the zero position, engaging the brakes, cutting off the electric current and securing the machine against any possibility of movement or accidental start-up during rest.	Death	7	1	3
		44. Parking in dangerous areas (within the range of action of the bucket wheel, on the CF when moving (translating) the machine, at coal dumping points, in areas with a danger of tripping over coal stacks, etc.).	Death	7	1	3
		45. Running the machine's power cord by hand - risk of unbalancing, bumping, catching and crushing or breaking hands.	Disability degree 3	4	2	3

		46. Falling from the same level by tripping, slipping, unbalancing when moving on the circulation paths from the external coal storage but also on the circulation paths from the machine.	ITM 3 - 45 zile	2	4	2
		47. Falling from a height (from a car) by slipping, tripping, unbalancing, leaning over railings, climbing on equipment without taking safety measures.	Death	7	3	5
		48. Faulty communication, non-synchronization between the two drivers of a work formation on the machine (e.g. performing rotation maneuvers, raising / lowering the arm, moving the machine, starting lanes, etc. without announcing and informing each other).	Death	7	1	3
		49. Sleeping in the cabin or in other areas of the machine.	Death	7	1	3
	d2. Omissions	50. Failure to use the protective equipment provided (individual protective equipment and protective devices).	Death	7	3	5
		52. Omission of some operations, for example: - failure to check the condition of machinery, brakes, lubrication mechanisms, electrical installations, etc. at the start and then periodically during the work; - starting the machine without giving the start sound signal, to warn the other workers; - cleaning, greasing or repairing machine parts in motion without stopping the respective equipment.	Death	7	1	3
		57. Failure to release the manual clamps for blocking the machine's translation, when it is put back into motion.	Death	7	1	3
		58. Failure to ensure the necessary visibility from the control cabin, due to the windows being dirty, blocked or frozen or due to the non-functioning of the lighting installations at night .	Death	7	1	3
		59. Omitting some preparatory operations for fixing faults: correct positioning, with the security devices and equipment that must be activated, disconnecting the electricity, bringing all controls to the zero position, etc..	Death	7	1	3

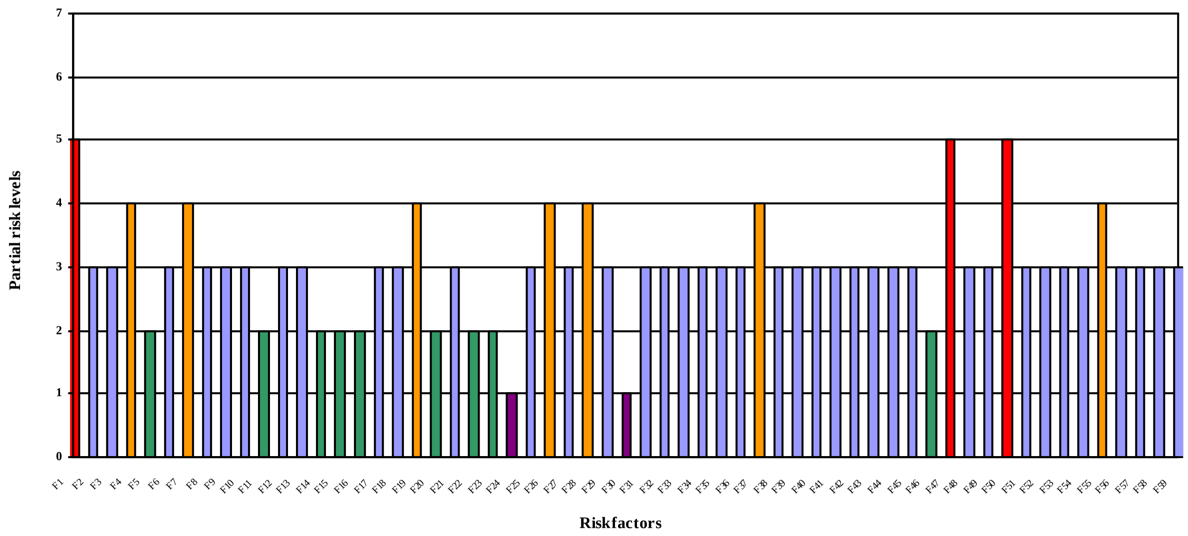

Fig.6. Partial risk levels of the identified risk factors for the job „Earth-coal mover machinist”

Calculation of the global risk level

$$N_{rgl} = \frac{\sum_{i=1}^{n} r_i R_i}{\sum_{i=1}^{n} r_i} = \frac{\sum_{i=1}^{59} r_i R_i}{\sum_{i=1}^{59} r_i} = \frac{2(1x1) + 9(2x2) + 38(3x3) + 7(4x4) + 3(5x5) + 0(6x6) + 0(7x7)}{(2x1) + (9x2) + (38x3) + (7x4) + (3x5) + (0x6) + (0x7)} = \frac{567}{177} = \mathbf{3,20}$$

Table 2 centralizes the prevention and protection measures proposed based on the evaluation, measures that will form the basis of the prevention and protection plan drawn up in accordance with the requirements imposed by the legislation in force.

Table 2. ***Extract Sheet of proposed measures for the workplace: Earth-coal mover machinist***

Crt. no	Factori de risc identificaţi	Partial risk level	Measures proposed for rosk mitigation
1.	1. Functional movements of technical equipment and machine parts in motion: translating (moving) the entire machine on the CF rail, turning / raising / lowering the arm, raising / lowering the belt rider, turning bucket wheel, running belts, rollers and tape drums , strippers and plows, discharge funnels and valves, servomechanisms (hydraulic cylinders), drums for electrical cables, etc.	5	***Technical measures*** - Maintaining in good condition the protectors and security casings of moving machine bodies; Their painting and inscription according to the norms of s.s.m.; - Keeping the blockages, interlocks, signals and devices for safety shutdown of the equipment in good working order; - Keeping the traffic lanes in good condition: railings, not to slide, not to be obstructed by the storage of materials, etc.; - During operation, only the presence of its attendants (2 people) is allowed on the machine; - Before putting the machine and the equipment on it into operation (e.g. conveyor belts), the sound signals established in the internal technical instructions will be given; ***Organizational measures*** - Review and permanent update of the s.s.m. documentation. (risk assessments, instructions, OSH plans, training topics, etc.); - Providing the appropriate personal protective equipment: non-slip shoes, tight overalls, helmet equipped with a chin strap, protective gloves, etc.
2.	47. Falling from a height (from a car) by slipping, tripping, unbalancing, leaning over railings, climbing on equipment without taking safety measures.	5	***Technical measures*** - Keeping traffic overpasses, stairs, work platforms in good technical condition; - Prohibition of storing materials, parts, tools on the combined machine in order not to block the circulation paths and work platforms; - Keeping the railings in good condition; - Erasing oil or vaseline stains from the roads; - Intervention in certain areas of the car, not protected by railings, will only be done using the seat belt. ***Organizational measures*** - Training of service personnel as well as repair personnel on the dangers and measures for safe movement at high heights (over 2 m) of the combined machine: only on arranged and maintained circulation paths, ensuring lighting, etc.); - Equipping personnel with protective equipment for working at height (safety belt, rope, mobile ladders).

Crt. no	Factori de risc identificaţi	Partial risk level	Measures proposed for rosk mitigation
3.	50. Failure to use the protective equipment provided (individual protective equipment and protective devices).	5	***Organizational measures*** - Training workers regarding the consequences of non-use or incomplete use or the use of inadequate personal protective equipment; - Verification of the wearing of protective equipment by workers, daily, carried out by the shift leader and/or, by survey, by hierarchical superiors. Prohibition of working without full protective equipment. Penalty for not wearing protective equipment.
4.	19. Risk of fire due to the presence of combustible and flammable materials: coal, coal dust, rubber tape, cable insulation, oils, greases.	4	***Technical measures*** - Casing according to the degree of risk presented by the dusty environment of electrical equipment (panels, panels, switches, terminal boxes, etc.); - Maintenance of electrical installations in good condition; Avoiding improvisations; Correct laying of cables; Grounding or grounding; - Thermal insulation of sources that release heat (bearings) by casing, shielding; - Permanent cleaning to eliminate possible sources of ignition: material (coal) fallen from the belts, dust deposits, oil leaks; - Prohibition of storing combustible / flammable materials under or on the combined machine; ***Organizational measures*** - Periodic training and testing of workers in the PSI field for the activity performed; - Review and permanent update of the specific internal PSI instruction for the combined machine; - Organization of fire protection at workplaces, according to the PSI legislation in force; - Establishing and setting up smoking areas according to the rules. Hygienic-sanitary measures - Equipping first aid kits with ointments and special medicines for burns; - Equipment of the Expl. Section Fuel with personal protection and rescue equipment and devices (gas and smoke masks, anti-caloric suits, PSI storms, stretchers, rescue ropes, etc.);

4. RESULTS INTERPRETATION

The global risk level calculated for the job ***Earth-coal mover machinist*** is equal to 3.20 - a value that falls into the category of jobs with medium risk level / medium security level. The result was obtained by drawing up the ***Job Evaluation Form***, from which it can be seen that out of the total of 59 identified risk factors:

- 0 falls into the category of *maximum risk factors* (level 7);
- 0 falls into the category of *very high risk factors* (level 6);
- 3 fall into the category of *high risk factors* (level 5);
- 7 fall into the category of *medium risk factors* (level 4);
- 38 fall into the *low risk class* (level 3);
- 9 fall into the *very low risk class* (level 2);
- 2 fall into the *minimum risk class* (level 1).

From a statistical point of view, regarding the distribution (weight, frequency) and level (value) of risk factors by types of generating sources, the situation is presented in fig.7:

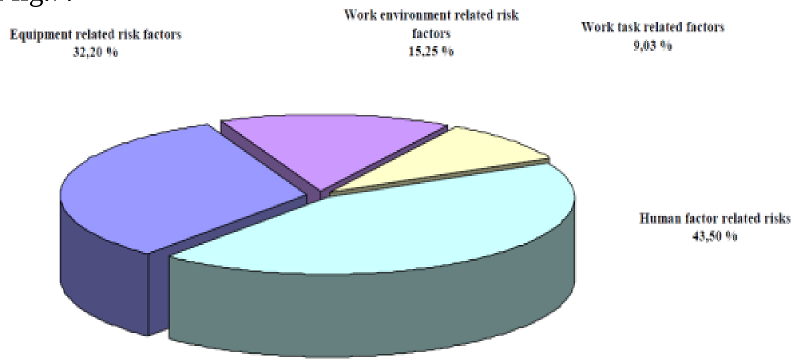

Fig.7. The share of the number of risk factors identified by the elements of the work system

It is noted that the main risk factors are the combined machine and the workers, so great importance will be given to the technical condition, working technology with the combined machine and the training and discipline of the workers. For a better interpretation and awareness, the distribution of risk factors is represented in the form of diagrams in fig.2 and fig.3. From the analysis of the Evaluation Form, it is found that out of the 59 identified risk factors, 40 can have irreversible consequences on the performer (35 death and 5 disability grade 3), i.e. 67.79%.

5. CONCLUSIONS

The research aimed at risk assessment and the development of the prevention and protection plan for the Paroşeni Power Plant Branch, in accordance with the legislation in force at national level in the field of safety and health at work. The study was developed based on the data provided by S.C. Complexul Energetic Hunedoara

S.A. – Paroşeni Power Plant Branch; through the job descriptions, 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 company's management and technical staff, as well as and the own observations made on the occasion of the documentation visits and follow-up of the activity for each workplace. The completion of the work consisted of 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 workplace;
- establishing the maximum foreseeable consequence of the action of the risk factors onto the human body, for each individual risk factor;
- classification in gravity classes;
- classification in 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.

The ranking of analysed workplaces, depending on the global level of risk, is shown in table 3.

Table 3. ***Ranking of investigated workplaces according to the global level of risk***

Nr. crt	**Workplace**	**Overall risk level**
1	Earth-coal mover machinist	3.20
2	Machinist at the drive head of the coal conveyor belts	3.085
3	Coal unloading operator	3.01

The overall risk level on company is:

$$N_{gS} = \frac{\sum_{i=1}^{14} r_i \cdot N_{gi}}{\sum_{i=1}^{14} r_i} = 3{,}098 \quad (2)$$

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} = 3.098, determines its inclusion in the category of those with a low to medium risk level.

This situation, good from the point of view of compliance with the legislation in the field of safety and health at work, is due both to the concerns of the designated worker (or the internal/external prevention and protection service) and to the efforts made by the management of the company, which integrates aspects of efficiency economic with those of safety and health at work.

Risk assessment must be carried out in a systematic way based on a defined and logical methodology. The starting point must be a general examination (analysis of the current situation) that reveals the situation of the enterprise from the point of view of safety and health at work.

The assessment of risks in an enterprise must be comprehensive enough to offer alternative solutions for combating occupational risks (preferably at the source) and to establish the ranking and priority of preventive measures. The scope and level of detail of a risk assessment must always respect the severity and probability of occupational risks. For this, it must be shown that the generally recognized dangers of an industrial branch are taken into account, but it must be demonstrated that concrete findings from the field, at a given time, were also taken into account. The risk assessment must be appropriate, in the sense that the depth of analysis and the level of measures must be different for major and minor hazards.

REFERENCES

[1]. 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.

[2]. Băbuţ G.B., Moraru R.I., Cioca L.I., *Kinney methods": useful or harmful tools in risk assessment and management process?*, Proc. of the 5th Int. Conf. on Manufacturing Science and Educations - MSE 2011, Sibiu, Romania, 02-05 June, vol. II, 315-318, 2011.

[3]. Băbuţ 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", **14** (137), 55-66, 2013.

[4]. Carter D.A., Hirst I..L., Maddison T.E., Porter S.R., *Appropriate risk assessment methods for major accident establishments*, Trans IChemE, **81**B, pp 12–18, 2003.

[5]. Cioca, L.I., Moraru, R.I., *Explosion and/or fire risk assessment methodology: a common approach structured for underground coalmine environments,* Arch. Mining Sciences, **57** (1), 53-60, 2012.

[6]. Fîță N.D., Lazăr T., Popescu F.G., Pasculescu D., Pupăză C., Grigorie E., *400 kV power substation fire and explosion hazard assessment to prevent a power black-out*, International Conference on Electrical, Computer Communications and Mecatronics Engineering - ICECCME, 16 – 18 November, Maldives, 2022.

[7]. Fîță N.D., Obretenova M.I., Pasculescu D., Tatar A., Popescu F.G., Lazar T., *Structure and analysis of the power subsector within the national energy sector on ensuring and stability of energy security*, Annals of the Constantin Brancusi University of Targu-Jiu, Engineering series, Issue 2 / 2022, pp.177-186, 2022.

[8]. Fîță N.D., Radu S.M., Păsculescu D., Popescu F.G., *Using the primary energetic resources or electrical energy as a possible energetical tool or pressure tool,* Proceedings of Sciendo International Conference Knowledge based organisation – "Nicolae Balcescu" Land Forced Academy Sibiu, Vol. XXVII, No. 3, pp. 21-26, 2021.

[9]. Handra A.D., Popescu F.G., Păsculescu D., *Utilizarea energiei electrice - lucrări de laborator*, Editura Universitas, Petroşani, 167 pag., 2020.

[10]. Ivaşcu, L., Cioca, L.I., *Occupational Accidents Assessment by Field of Activity and Investigation Model for Prevention and Control*, Safety Journal, **5**, pp. 12, 2019.

[11]. Kokangül, A,, Polat, U., Dağsuyu, C., *A new approximation for risk assessment using the AHP and Fine Kinney methodologies.* Saf Sci 91:24–32, 2017.

[12]. Lazăr T., Marcu M.D., Uțu I., Popescu F.G., Păsculescu D., *Mașini electrice - culegere de probleme*, Editura UNIVERSITAS, Petroșani, pp.197, 2023.

[13]. Moraru, R.I., Băbuţ, G.B., *A Romanian occupational health and safety risk assessment tool: premises, development and case study*. In: *Risk assessment and management*, Zhang, Z. (Ed.), Academypublish.org (Publishing Services LLC), Cheyenne, WY, USA, pp. 292-311, 2012.

[14]. Niculescu T., Pasculescu D., Pana L., *Study of the operating states of intrinsic safety barriers of the electric equipment intended for use in atmospheres with explosion hazard*, WSEAS Transactions on Circuits and Systems, Volume 9, pp.430-439, 2010.

[15]. Pasculescu D., Romanescu A., Pasculescu V., Tatar A., Fotau I., Vajai Ghe., *Presentation and simulation of a modern distance protection from national energy system*, Proceedings of the 10 th International Conference on Environment and Electrical Engineering – EEEIC 2011, Rome, Italy, pp. 646-650, 2011.

[16]. Pasculescu D., Slusariuc R., Popescu F.G., Fîță N.D., Tatar A., Lazar T., *Modeling and simulation of lighting of a road with 2 strips per direction to en 13201: 2015 Standard*, Annals of the University of Petrosani, Electrical Engineering, Vol.24, pp.65-74, Petrosani, 2022.

[17]. Pasculescu, V. M., Radu, S. M., Pasculescu, D., Niculescu T., *Dimensioning the intrinsic safety barriers of electrical equipment intended to be used in potentially explosive atmospheres using the simpowersystems software package*, Papers SGEM2013/Conference Proceedings, 417- 422 pp, Vol. Science and technologies in geology, exploration and mining, Bulgaria, 2013.

[18]. Pece, Ş., *Risk assessment in the work system*, Publishing House Rubin, Galaţi, 2010.

[19]. Popescu F.G., Pasculescu D., Marcu M., Pasculescu V.M., Fîță N.D., Tatar A., Lazar T., *Principles of effective energy management and power control system*, Annals of the University of Petrosani, Electrical Engineering, , Vol.24, pp.111-118, Petrosani, 2022.

[20]. Popescu F.G., Păsculescu D., Păsculescu V.M., *Modern methods for analysis and reduction of current and voltage harmonics,* LAP LAMBERT Academic Publishing, ISBN 978-620-0-56941-7, pp. 233, 2020.

[21]. Romanian Parliament, *The 319/2006 Act on Occupational Health and Safety*, Oficial Journal of Romania, Part I, No 646/26.07.2006

[22]. Romanian Government, *H.G. no. 1425/2006 for the approval of the Methodological Norms for the application of the provisions of the Law on safety and health at work no. 319/2006*, Official Gazette of Romania, Part I, no. 882 / 30.10.2006.

[23]. Romanian Government, *H.G. no. 955/2010 for the modification and completion of the Methodological Norms for the application of the provisions of the Law on safety and health at work no. 319/2006, approved by H.G. no. 1425/2006,* Official Gazette of Romania, Part I, no. 661 / 27.09.2010.