OCCUPATIONAL RISK ASSESSMENT AT BRANCHES OF MINING DIVISION WITHIN HUNEDOARA POWER COMPLEX: USUAL TOOLS

Gabriel Bujor BĂBUȚ, Roland Iosif MORARU**, Mihaela TODERAŞ*, Mihai POPESCU-STELEA****

Abstract: *The thorough analysis of undesired events occurred in the Jiu Valley collieries, such workplace accidents, occupational diseases, near-misses, coal mine fires, self-heating phenomena, methane and coal dust explosions, safety indexes analysis, the related costs and the loss of production costs should be the ground that underlies the establishment of any policy in the occupational health and safety field. This paper proposes an overview and critical analysis of the three risk assessment methods most commonly applied at Branches of Mining Division within Hunedoara Power Complex for occupational risk analysis, respectively the INCDPM Bucharest method, Job Safety Analysis and Energy Analysis, to highlight they strengths and drawbacks in order to increase the efficiency of their application, with the consequence of improving the workers' level of health and safety at work.*

Keywords: *occupational health and safety (OHS), risk analysis, job safety, energy, work task*

1. Introduction

To elaborate the occupational health and safety policy, to establish objectives of the occupational health and safety field, it is necessary to conduct a comparative analysis of risk assessment techniques applied to the mining units from Jiu Valley.

Recognizing the fact that the current organizations are socio-technical systems characterized by a high level of complexity, however, we consider that the basic levels of the related work processes are unchanged [9]. Therefore, we consider that in the development of an own mental model, OSH professionals must admit the strengths and limitations of different models and to be able to evaluate critically the most suitable models for practical application. In the same time, the OSH specialist must have the ability to distinguish between "what is happening" in the occupational system and what "should happen", in order to differentiate the models in relation with the applicable analysis methods based on a model [2]. The increase of the safety level of any occupational system involves identifying risks and establishing means of prevention and protection intended for their control [4], [8]. As stated by Pece [11], the key issue of the access for optimizing the human integration occupational demands system, to conservation and efficient use of its creative potential, is today a multidisciplinary field that integrates joint concerns of the technical and humanistic subjects, both interested in finding the most appropriate specific means of the occupational system [7] (Figure 1).

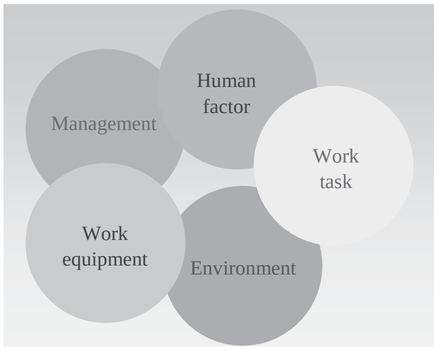

Fig. 1. *The human factor in the occupational system*

The understanding of the risk requires knowing its structure and its mode of manifestation, consequently, entering into its complexity and in all fields of knowledge. This requires a comprehensive approach and sometimes complex but, paradoxically, life is a continuous risk and there is no progress that would increase our comfort without any risk [5].

The adoption of the decision regarding risk can be represented as a decision tree with two possibilities: a gain having "P" probability or a loss with "1 - P" probability (Figure 2) [6].

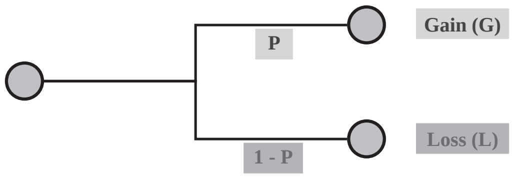

Fig. 2. *The adoption of the decision regarding risk*

* *Assoc.Prof.PhD.Eng. - University of Petroşani*
** *Prof.PhD.Eng. - University of Petroşani*
*** *PhD.-Student.Eng. - University of Petroşani*

The three risk assessment methods applied to Jiu Valley mining units are evaluation methods that may lead to the identification of the central dangerous events, but they cannot present a thorough analysis of the causes that lead to a major event or they cannot explain in detail the consequences arising from a system failure or a human error, as it happens when applying the Fault Tree Analysis and/or Events Tree [10].

2. The I.N.C.D.P.M. Bucharest method

In the mining units from Jiu Valley and - in general - our country, the method elaborated within INCDPM Bucharest is the most utilized method of analysis and risk assessment. This method is aimed for the quantitative determination of the risk/safety level for a job, sector, and enterprise based on the systemic analysis and risk assessment of accidents and occupational disease [3], [11].

The result of the analysis and risk assessments materialize into a centralizing document named "job assessment sheet" that contains the level of global risk. Starting from this document, the prevention programs of occupational accidents and diseases are drawn. The elaborators of the method have established a checklist for the analyzed system that helps greatly the evaluation team to identify all the risk factors. Also, through the theoretical model of the method there are described all the steps that must be followed to quantify the size of the risk based on the combination between the severity and the frequency of maximum foreseeable consequence and the establishment of the risk/safety level. The safety level for a workplace is inversely proportional with the risk level. The I.N.C.D.P.M. method can be applied in any activity field, in all the stages of life of a workplace, respectively from: conception, feasibility study, design, construction, acquisition, reception/putting into commission, operation, maintenance, modification, and shutdown. To ensure a good risk analysis and assessment, using this method, it requires that the evaluation team to be multidisciplinary to identify all the risks (especially their concrete form at the workplace), and to assess correctly these risks.

The method includes the following mandatory steps:

1. defining the system to analyze (workplace);
2. identifying the risk factors in the system;
3. risk assessment of accidents and occupational disease;
4. risk ranking and priority setting of prevention;
5. prevention measures proposal.

The steps required for assessing occupational safety in a system described previously, are performed by using the following working instruments:

a. *The list of identifying risk factors*. The risk factors are grouped according to the generator element of the occupational system (executor, work task, means of production and work environment).
b. *List of possible consequences of the actions of risk factors on the human organism.* It is a helpful instrument to estimate the severity of the consequences.
c. *Quotation scale of severity and probability*. The quotation scale of severity of the consequences is based on medical criteria of clinical diagnosis, functional and work capacity assessment developed by the Ministry of Health and Ministry of Labor, Family and Social Protection. In terms of probability classes, following the experiments it was opted the final form of the method for European Union standard adaptation, so instead of the specified intervals were taken into account:
    - Class 1 → event frequency: once over 10 years;
    - Class 2 → event frequency: once in 5 - 10 years;
    - Class 3 → event frequency: once in 2 - 5 years;
    - Class 4 → event frequency: once in 1 - 2 years;
    - Class 5 → event frequency: once a year - 1 month;
    - Class 6 → event frequency: less than once a month.
d. *Risk Assessment Grid.* With the help of the grid it is realized the effective expression of the risks in the analyzed system in the form of torque - frequency of occurrence.
e. *Classification scale of risk levels, respectively levels of safety.* It is built on the grid of risk assessment, it is a tool used to assess the level of risk foreseen, respectively of the safety level.
f. *Job sheet* - centralizing document of all operations to identify and assess the accident risks and/or professional diseases.
g. *Sheet of proposed measures.* It is a form for the centralization of the preventive measures that are necessary to be applied, results from the workplace evaluation in occupational safety.

The global risk level "N_r" of the occupational system is calculated as a weighted average of the risk levels established for the risk identified factors:

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

where: N_r is the global risk level of the occupational system; r_i - the risk factor rate i; R_i - the risk level for the risk factor i; n the number of risk factors identified in the occupational system.

In the case of the assessment of some macro-systems (sector, section, company) from the assessment of occupational micro-systems (jobs, equipment) the global risk level of the macro-system is calculated as a weighted average of global risk levels calculated for each labor system from the composition of the macro-system. To establish the prevention measures, identified risks, assessed will be taken into account in descending order and the establishment of the measures will take into account the ranking criteria of the measures, namely: the risk elimination, risk containment, risk avoidance, worker confinement [1].

3. Job Safety Analysis

Here, we are dealing with a method used in units, for workplaces where workers perform manual activities on/or near a machine production or a technical equipment [4].

The method is suitable especially for work tasks well enough defined (limited). The object of analysis may consist for example in a limited number of work tasks performed in a production cycle. Then, a list is covered point by point, trying to detect the different risks. The analysis should lead to the adoption of measures both technical and organizational.

The stages that must be completed when applying the method of occupational safety analyze are the following:

1. preparation;
2. structuring - drawing up the list of work tasks and operations conducted to meet them;
3. identifying the risk sources;
4. the risk assessment;
5. risk evaluation;
6. proposal of prevention measures;
7. completion.

In the preparation phase, the necessary information are gathered, work tasks and situations are to be analyzed are identified, the operations that are performed within each work task are identified; all participants in the analysis are selected and instructed. Information base consists of: description of the tasks, work instructions, technical books of machines, maintenance instructions, reports on cases of injury, occupational diseases and dangerous incidents, interviews with employees, shooting videos. The informational basis is needed to achieve a more complete list of operations that are carried out as well as to identify the risk sources.

At identifying the work tasks and situations that will be analyzed, the following will be considered: training before starting work, initiate the production process, how work is carried out under normal conditions, measures to be taken in case of some flow disturbances of the production and how they are applied, transfers within and between work tasks, how does the production process end, maintenance and repairs, order and cleaning, how does the work end.

For the inventory of risk sources: the employees are interviewed, managers and coordinators of the production process, the way in which work is carried out is followed, the list of possible risks is used, problematic situations are sought out, technical equipment failures and shortcomings of the work methods are sought out, deviations from the normal development of the work stages are looked for (Table 1).

Within this method there are not separately estimated the probability and severity, but it appeals to a risk assessment practice, as follows in Table 2.

Table 1. *List of possible risks and risk sources*

Risk	Risk source	Risk	Risk source
Stumble	- Steep stairs - Loose objects, unfixed, which may constitute impediments at the workplace or on the access routes - Unevenness - Inappropriate lighting	Burns	- Flames - Steams - Corrosive liquids, molten metal - Chemical substances - Substances/materials extremely hot or cold
Sliding	- Slippery floors, wet, wet traffic routes covered with ice	Intoxications	- Gas/liquid spills - Handling chemical substances
Fall	- Protective railings are missing or broken - Climbing on machinery - Unevenness - Stairs or improper scaffolds	Drowning	Containers poorly protected

Risk	Risk source	Risk	Risk source
Grip	- Moving machine components - Falling objects - Narrow workspace - Inadequate working tools	Choking, suffocation	- Closed and narrow workspace - The oxygen is replaced by other gases - Accidental burial under materials
Muscle strains	- Lifting heavy weights - Vicious body positions - Uneven floors	Muscular-skeletal disorders	- Equipment improperly placed - Workspace improperly arranged - Monotonous and repetitive tasks - Manual lifting of heavy loads
Injury by striking/ impact	- Moving machine components - Falling objects - Car Parts protruding or that exceed working surface - Inappropriate tools - Acts of violence	Exposure	- Dust, fumes from chemicals substances, biological agents - Noise, Vibration - Thermal radiation - Electromagnetic fields - Chemical substances - Organic solvents
Injury by cutting	- Tools, corners or sharp edges - Design of particles from polishing/splintering	Electrocution	- No disconnecting from the electric power source - Work equipment, insulators, etc. unsuitable - The lack of grounding

Table 2. *Quotation scale of risks*

Code	Description
0	Negligible risk
1	Acceptable risk - no need to take action
2	Certain risk - it is recommended to take action
3	High risk level - measures must be taken
4	Very high risk - measures must be taken immediately

For each work task is drawn a sheet that includes the following categories: operations, risks / risk sources, risk assessment, measures. At each operation within a task, more risks can be identified; each risk may have multiple sources of risk [9]. In order to establish prevention measures, the identified and assessed risks will be taken into account in descending order and at the establishment of measures will take into account the ranking criteria of the measures, namely: risk elimination, risk containment, risk avoidance, worker confinement.

4. Energy analysis

Energy analysis is based on the following principle: for a person to be injured, the person must first be exposed to the influence of the *"Energy"* [4].

In this method, the energy term has a broad understanding. The energy is something that can injure a person physically or chemically during an incident. The injury occurs when the human organism is exposed to the influence of an energy force exceeds the resistance of the organism. Dangerous energies can be of several types: they could be objects falling from heights, structures or voltage in collapse, meaning energy in the traditional sense of the word. If we take into account toxic or corrosive substances, we obtain a comprehensive picture of what is considered as "energy" within the meaning of this assessment method. It is considered "energy" any external factor that has the ability to affect the human body. To identify *"the energies"*, the method developer has established a list of *"energies"* having the potential to harm the human body (Table 3).

Table 3. *The list of "energies" that may injure the human organism*

1. Gravitation, height Personnel working at height Objects at height Structures in collapse Handling, lifting, etc.	6. Warmth and cold Objects Liquids and molten materials Steam & Gas Chemical reactions

2. Linear motion Moving machine components Projected items, splash Handled materials Motor vehicles	7. Fires and explosions Materials and flammable gases Explosive materials, gas & steams, powders Chemical reaction
3. Circular motion Machine components Transmission of energy Rolls	8. Chemical effects Toxic, Corrosive, Asphyxiating Infections Other acute effect
4. Accumulated pressure Gas, Steam heating, Liquid Bows Tensions within the material	9. Radiations Acoustical, Electromagnetic Light, inclusively infra and ultra rays Ionizing radiation
5. Electrical voltage Current (inclusively accumulation and thermal) Condenser, Battery	10. Diverse People's movements Sharp edges, Sharp objects

Phases covered in the application of the energy analysis assessment method are:

- preparation;
- system structuring, dividing in components;
- identifying the energies and risks;
- risk assessment;
- establishment of preventive measures;
- completion.

The purpose of the structure is to divide the technical equipment in components that can be subsequently analyzed in turn. For example: *input → processing → output*.

In general, the division is made according to the physical form. The object is divided into components. If the production line is continue, it goes from one end to the other. After dividing into components, all energies that are powerful enough to produce injure to the human organism are identified. Each energy type might lead to the appearance of a risk or more risks. In order to establish the prevention measures, the identified and assessed risks will be taken into account in descending order and at the establishment of measures will take into account the ranking criteria of the measures, namely: energy elimination, reduction of the quantity of energy, preventing the formation of higher energy, preventing the release of energy, the controlled reduction of energy, the separation of the worker from the energy flow in space and/or time, energy source protection, worker protection, the reduction of consequences (in case the event took place).

5. Conclusions

All the three methods used at the mining units from Jiu Valley use checklists prepared by the developers of this method, the INCDPM method, a list of the risk factors grouped after the generating elements of the occupational system, the occupational safety analysis method is a list of risks and sources of risk having as the central element the executor, the energy analysis method is a list with "energies" large enough to cause harm.

INCDPM method aims to determine quantitatively the level of risk/safety for a workplace, sector, and enterprise based on systemic analysis and risk assessment of accidents and occupational disease. The occupational safety analysis methods and energy analysis lead to a semi-quantitative determination. Numerous data obtained from the quantitative risk analysis can be used as risk indicators that can be the basis for decision making. For complex activities (mining, chemical, petrochemical, aerospace, production of nuclear power), where major events can produce, the initial procedure must be followed to identify all dangerous central events. The risk estimation involves comparing the estimated levels of risk with defined risk criteria to determine the significance of the level and type of risk.

As we have shown in the paper, it is important to note the fact that the risk assessment process for estimating the probability of one approach requires also the use of relevant historical data in order to establish their probabilities of occurrence in the future. Therefore to achieve an efficient system to increase the occupational safety and health in the mines from Jiu Valley, we should not forget anything, we have to learn from the events that took place and take the appropriate measures that have to be made in order that these events will not recur. "A priori" risk analysis and "a posteriori" analysis of the accident will be done taking into account all the parameters relating to all types of malfunctions that may occur. In the case of "a priori" analysis, the aim is to determine all the possible causes that may lead to the undesirable event. In contrast, at "a posteriori" analysis of an undesired event the cause is aimed, meaning chaining the factors that led to the respective event. Equally important is the realization of the distinction between cause and condition, which are close concepts that sometimes can be confused. However this distinction depends on context.

Risk management facilitates a structured and systematic approach of the decision-making process. The value and force of the risk management approach lies in the fact that it combines various *assessment and consultation techniques*, uniting them into a whole that gives consistency to the decision-making approach. The risk management offers to any organization the ability to better understand the conduct of operations and the ability to respond more effectively to internal and external circumstances changes.

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