

ENSURING THE SAFETY AND PRESERVATION OF THE HEALTH OF THE WORKERS BY THE USE OF PERSONAL PROTECTIVE EQUIPMENT (PPE) IN THE MINING INDUSTRY

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ABSTRACT: *Being a multidisciplinary industry, the mining is based on many professions and occupations in which workers are exposed to various risks of specific activities they carry out. Given the risks to which they are exposed, the article aims to address the proper importance in selecting and using appropriate personal protective equipment to ensure the health and safety of workers.*

KEYWORDS: *mine, dangers, protection, personal protective equipment*

1. INTRODUCTION

From ancient times, the mining industry in Romania has provided a wide range of mineral products such as coal, oil shale, salt, ferrous, non-ferrous, aluminum and aluminous rocks, noble metals, radioactive, rare earth, precious and semiprecious stones, peat, used as is or as raw materials, paving the way to civilization, actively supporting the economic development of the country.

Even the Romanian economy is restructuring and diminished the overall consumption of resources, latest statistical surveys show that in Romania there are currently 14 mining areas, being considered the seventh country in the European Union (EU) according to the value added created by mining and quarrying and second in terms of labor working in this sector.

Traditionally classified in surface mining and underground, mining is a multi-disciplinary industry based on many professions and occupations in which workers are exposed to various hazards specific to the activities they carry out. Thus, in the activities related to:

- geodesy / topography of the land, workers are exposed to hazards due to the presence of land / soil uneven and / or slippery, jobs at height, objects falling from height, stored energy that can be released quickly and can cause injury (eg shock by dropping off vehicles) harmful energy sources such as powerful optical radiation (solar); ambient conditions which can cause hypothermia or heat stress;
- cleansing the land to site preparation - activity which includes cutting down the trees, demolition of the buildings and removal of the upper layers of soil - main hazards related are cut falling trees hitting workers, hitting pieces of material resulting from the demolition of buildings, damaging energy sources

such as strong optical radiation (solar), the electricity, the strong noise, the vibration, the temperature conditions from environment which can lead to hypothermia or stress due to the heat, fire and explosions, burns from the contact with equipment or objects with very high or very low temperature, manual handling, sources of sharp objects, sharp, rough (work equipment, work object) which parts of the body may come into contact; repetitive work; inadequate workspace; ergonomics unadvised;

Construction of roads and buildings - the dangers are due to the presence of overhead electricity, working at heights and various machinery in motion;

For drilling the main hazards are those related to:

- the working at height when workers are at the risk of falling over the edge of the drill,
- the presence of hazardous chemicals used at work or degradation of hazardous chemicals apparently by improper storage, contact between incompatible substances, accidental ignition, inhalation of vapors, gases or aggressive/caustic or toxic particles, contact with vapors, gases or aggressive/caustic or toxic particles, ingestion of vapors, gases or aggressive/caustic or toxic particles;
- presence of dust created during drilling operations,
- noise,
- involvement or hit by a moving part of the drilling equipment.

If in the surface mining hazards are easily identified, for underground mining things are complicated by the emergence of new risk factors such as:

- working in enclosed space,
- danger due to low oxygen content and the presence of gas accumulations in mine (natural

gas or carbon dioxide) which are potentially explosive;

- work orientation in space, which can be horizontal - gallery, stope, inclined - inclined plane, rolling, vertical or highly inclined - pit, upward way (works on very inclined lower section, which provides communication between the two levels).

Since mining is a sector where workers are exposed to various risks (work in enclosed spaces, lack of oxygen, soil instability and layers, explosions, floods, the presence of dust and other gases, etc..) and improper architectural and organizational solutions and or poor planning work can negatively impact human, financial and economic level, over time has been granted attention to measures that prevents and maintains health and safety of workers. Thus, improving the safety and health of the workers at work it is not only important to cut human suffering of workers, but also a way to ensure the success and sustainability of businesses by a better development of economic for long-term.

On the national scale the law that establish measures to promote improvements in the safety and health of workers is Law no. 319/2006 - Occupational Safety and Health (national transposing the Framework Directive 89/391/CEE). This establishes that the risk assessment in the workplace, which means identifying all hazards acting together and /or cumulatively, while imposing and implementing a policy for the risk management at work and adopting decisions regarding protective measures to be taken including, if appropriate, the protective equipment to be used.

Personal protective equipment (here inafter abbreviated as PPE) should be the last measure of protection, which applies only where a risk assessment has demonstrated that the use of other, safer work equipment or workplace reorganization to eliminate the risk is not possible and the work can be performed safely only by using PPE. According to Article 3 (1) of HG 1048/2006 "The PPE shall mean any device designed to be worn or held by the worker to protect against one or more risks which could endanger the safety and health at work and any additional item or accessory designed for this purpose. "

Considering the potential risks of mining to the workers, the proper PPE selection and use of them has a particular importance in ensuring the health and safety of workers. However, selection of the appropriate PPE to ensure a high level of protection against the existing risks at the work are done only after making a proper assessment, considering:

- "a) the analyzing and assessing the risks that can not be avoided by using the other means;
- b) the defining of the characteristics required to personal protective equipment to be effective where it provide protection against the risks considering any risks that the equipment itself may create;
- c) comparing the characteristics of the personal protective equipment available with the characteristics of the workplace. "[5]
- d) the presence of conformity mark "CE" accompanied by the standard / standards whose

requirements it meets (being used to protect the health and safety of workers at work, designing, manufacturing and marketing of a PPE are regulated by Directive EU 89/686/EEC (implemented at national level by HG 115/2004 with subsequent amendments).

Because the directive/HG defines only the basic requirements to be met by personal protective equipment in order to present a proof of compliance with these basic requirements, it is essential to use the harmonized European standards, which gives to these products a presumption of conformity with the referred essential requirements.

Also, a special attention should be given to indoor jobs where the gases, dusts, vapors of flammable liquid or powders, mixed with the air or other oxidizing agent could be ignited by static electricity. The ease with which they can be ignited depends by a number of factors such as dissolved oxygen, temperature and pressure. Sources of potential ignition include electrical discharge generated by static electricity present in people, clothing, used equipment, materials, produced or processed products.

The risk associated with the electrostatic discharge arising from the PPE depends by the presence and sensitivity to ignition of explosive atmospheres. For the air containing hydrocarbons the range is between about 1% and 15% by volume. Combustible substances, for example, hydrogen, acetylene and carbon disulfide, are particularly dangerous. Electrostatic charges may be produced by rubbing two parts of the same EIP (friction between sleeve and clothes, rubbing one leg of the other) or friction between two PPE (friction between clothes and PPE used to protect against falls from height).

2. PERSONAL PROTECTIVE EQUIPMENT THAT CAN BE USED IN MINING

Starting from the existing main risks at the work further will be presented the types of PPE that can be selected to provide protection of workers in the mining sector considering the hazards present in the workplace and the anatomical area exposed to the risk of injury.

a. Head protectors

PPE designed specifically to protect the top of your head against the risk of injury by falling objects are helmets.

Selection of appropriate helmet is made only after evaluating the risks from work, considering:

- the nature and the intensity of the risk (injury of scalp by hitting his head against hard objects; injury with objects falling from above (vertical direction), medium risk (general) injury from objects that are thrown (in the vertical direction, only to the head and side of body) - high risk level; injury from impact with hard objects during specific activities;
- Environmental conditions;
- The existence of additional risks (risk of electrocution);

- Other complementary risks (molten metal thrown, radiant heat, compression, in case of entering to tight spaces).

So, when in the workplace there are hazards:

- mechanical (falling objects, shocks, lateral crushing, bolts mounting), thermal (splashes of molten metal) and electrical for a maximum power voltage of 440 V, helmets are used with features (such as shock absorbing capacity, puncture resistance, lateral rigidity, flame resistance, electrical insulation) that meet the requirements of EN 397:2012+A1:2012 - "Industrial safety helmets" and EN 14052:2012+A1:2012 - "High performance industrial helmets";
- Electric (work on or near the energized systems up to 1000V AC or 1500 V DC) using helmets that prevents the passage of dangerous electrical current through the body when used with other electrical PPE. Helmets must meet both electrical requirements of EN 397:2012+A1:2012 and EN 14052:2012+A1:2012 regarding the ability of shock absorption, puncture resistance, lateral rigidity and related features mentioned for electrical resistance in EN 50365:2002- "Electrically insulating helmets for use on low voltage installations").

To increase visibility, color for helmets can be chosen depending by the day time of the activities so signaling colors which enhance the visibility during the day are fluorescent red, fluorescent yellow and fluorescent orange-red; for night time, helmet visibility can be increased when applying beam headlight using retro reflective tape.

Regarding underground mining in mines susceptible to firedamp can be used industrial helmets and high performance helmets for industry since for normal use they are not subject to friction, so it cannot be loaded with the electric charges to generate an explosion. Therefore, in workplaces with potentially explosive atmospheres helmet was planned to not be removed from the head because rubbing the hair electrostatic discharge can generate an explosion.

b. Eye and face protectors

Whenever there are risk of injury to the eyes and face by shock characterized by varying degrees of severity (flying objects or particles), optical radiation, splashes of molten metal and hot solids, liquid chemical splashes, dust, gas, electric arc from short-circuit, or from any combination of these risks, there are used PPE for eye and face protection such as safety glasses with or without side shields, goggles, visors / face shields of different sizes with or without filters for welding.

Thus, during cutting operations, grinding, cutting, masonry works, drilling, chiseling, riveting, grinding, depending by the energy of impact flying objects or particles (determined in the step for risk assessment) may be used:

- Glasses with arms, goggles, face shield - when the impact energy is low (F);
 - Goggles, face shield - when the impact energy is medium (B);

- Face shields - when the impact energy is high (A);

Protectors intended to provide protection against molten metal and hot solids are mask-glasses or face shield; mask-glasses and facial displays are designed to provide protection against optical radiation and must provide at least the same level of protection against optical radiation as that conferred by a filter for ultraviolet, infrared or solar. Protectors intended to protect against drops and liquid splashes are mask-glasses (to protect against drops) or face shield (to protect against liquid splashes); Eye protection against short-circuit arc is only provided by face shields, whose metal parts must be covered.

PPE of face and eye provides adequate protection if it has CE marking and the number of standard whose requirements are fulfilled:

- EN 166: 2001 „Personal eye-protection - Specifications“
 - EN 14458:2004 “ Personal eye-equipment - Faceshields and visors for use by firefighters' and high performance industrial safety helmets used by firefighters, ambulance and emergency services“
- and one of the following standards specific to protection filters:

- EN 169:2002 „Personal eye-protection - Filters for welding and related techniques - Transmittance requirements and recommended use“,
- EN 170:2002“ Personal eye-protection - Ultraviolet filters - Transmittance requirements and recommended use“,
- EN 171:2002 “ Personal eye-protection - Infrared filters - Transmittance requirements and recommended use“,
- EN 175:1997 “ Personal protection - Equipment for eye and face protection during welding and allied processes“,
- EN 379:2003+A1:2009 „Personal eye-protection - Automatic welding filters“,
- Personal eye protection - Mesh eye and face protectors “Personal eye protection - Mesh eye and face protectors“.

In areas where there is danger of explosion, must be eliminated any action to PPE (cleaning finder, remove EIP) due to friction that could lead to a static loading, unloading could cause an explosion.

c. Hearing protectors

When the risk assessment found that workers may be exposed to a noise level that exceeds 85 dB (A), it is mandatory to provide them PPE against noise. To ensure adequate protection, users should consider the noise frequency in the workplace and the level of exposure to the noise. Protection against noise can be achieved by earplugs (which are inserted directly into the ear, usually disposable), earmuffs - (shells, earmuffs) mounted on flexible mountings or spring, which can be installed directly on the head, ear mounted on a helmet, industrial helmet soundproofed.

For ear muffs mounted on helmet attenuation is different from a helmet to another and therefore such

PPE should be used only with those specified by the manufacturer industrial headphones and not other models. We must also consider the fact that any antiphon reduce any sound and affect language communication. Jobs where this would lead to increased risks for workers, it may be necessary to use level-dependent attenuation earplugs or audio communication.

In areas where there is danger of explosion (underground mining), earplugs that fit inside the ear are too small to be considered an electrostatic hazard and there are not required precautions against static electricity. However for ear muffs clamping plate must be made of an insulating material whose maximum size depends on the ability of gases and vapors ignition (expressed by representative groups I, IIA, IIB, IIC (IEC 60079 - 20-1)), or dust representative group III (IEC 60079-0) and the classification of the hazardous area.

d. Respiratory protectors

Due to their work in the mining sector workers are frequently exposed to the risk of occupational disease because of the presence of different powders or lack of oxygen in the workplace.

Respirators are generally used only for short periods of time (limited duration); they are not intended to replace possible technical solutions.

Since absorption of harmful substances in the body can lead to lung disease (pneumoconiosis, silicosis, etc.) because of the inhalation the coal dust and other particulates present in the work environment, in addition to proper ventilation, the main measure for personal protective existing for workers against dust in the workplace is the use of half masks for particles filtering (FFP1, FFP2 and FFP3) according to EN 149:2001+A1:2009 „Respiratory protective devices - Filtering half masks to protect against particles - Requirements, testing, marking”. In their selection should be considered both the particle size and the characteristics of clogging for the filter, following in the same time manufacturer's instructions.

If Gassy mines, where the danger of explosion is imminent it is necessary to equip workers with respiratory protective equipment independent with closed circuit, with oxygen chemically generated, according to EN 13794:2002 “EN 13794:2002 Respiratory protective devices - Self-contained closed-circuit breathing apparatus for escape - Requirements, testing, marking”

e. Hand protectors

If the risk assessment will prove that during activities at the workstation hands of the workers may be exposed to various risks due to rough handling objects with sharp edges, sharp, hot, handling chemical containers, welding operations, activities at low temperature activities in electrical installations, activities in areas with potentially explosive atmosphere, causing the risk of injury must be given

suitable protective gloves. When selecting gloves should consider both the specific activities of the workstation and the work environment. Thus, the use of rotary work equipment (drills, screw machine powered) protective gloves should be selected to have a low resistance to tearing, thus preventing the risk of injury as a result of catching the glove by machine parts moving.

When work is carried out in potentially explosive areas, gloves must be selected to provide also protection against the electrostatic discharge. Gloves designed to be worn in such areas should be made of conductive or dissipative materials. The use of such gloves is only effective when the carrier is connected to ground through a low resistance of $10^8 \Omega$ (e.g., by wearing the proper shoes such as safety shoes that meet the requirements of EN ISO 20345:2011 „Personal protective equipment - Safety footwear (ISO 20345:2011)” and protective clothing to satisfy the requirements of EN 1149-5:2008 „Protective clothing - Electrostatic properties - Part 5: Material performance and design requirements”. Uses of gloves made of insulating materials is not recommended in areas with potentially explosive atmosphere because they do not allow dissipation of electrostatic charges accumulated through handheld objects.

f. Leg protectors

Personal protective equipment designed to protect the feet against risks in the mining industry is security footwear. Considering the existing risk factors in the workplace the recommended safety shoes are made entirely of rubber or polymer fully equipped with insertion for antiperforation with different electrical properties, due to their specific hazards. Thus, when handling explosives and an electrical shock hazard of an voltage equipment has been removed, is recommended as soon as possible the use of conductive footwear (whose resistance is $100 \text{ k}\Omega$) whose role is to minimize accumulation of electrostatic charge.

If gassy mines, antistatic footwear is recommended in conjunction with conductive or dissipative flooring as a means of dissipating static electricity of the user, thus avoiding the risk of ignition of vapors or flammable substances. In general, resistance to earth through antistatic footwear and conductive flooring should be between $100 \text{ k}\Omega$ and $1000 \text{ M}\Omega$, and if shoes will not provide user properly grounded should be used additional devices (bracelets grounded).

Whenever there is a risk of electric shock from involuntarily contact with damaged electrical the insulated footwear is recommended.

g. Protective clothing

Personal protective equipment that covers or replaces personal clothing is designed to protect against one or more hazards considering the anticipated duration of use, environmental conditions, user movements and positions during his work or when he engage in other activity. Because miners can be exposed

to explosion, selected clothing must be both dissipative electrostatic (to satisfy the requirements of EN 1149-5:2008) and must provide protection against heat and flame (to satisfy the requirements of EN ISO 11612:2008 „Protective clothing - Clothing to protect against heat and flame (ISO 11612:2008)”) and has to be able to signal the user's visual presence to be easily detected in dangerous conditions (to meet the requirements of EN ISO 20471:2013 „High visibility clothing - Test methods and requirements (ISO 20471:2013, Corrected version 2013-06-01)”).

h. PPE for working at height

PPE for work at height is used:

- every time when working at a height greater than 2 m, measured from the worker feet to the ground (base) or any other artificial baseline, base to which there is a danger of falling into the gap and
- a risk assessment has demonstrated that the work can be performed as safely as possible during the use of PPE and using other equipment is not possible to be safer and worker and a sufficient number of available workers

have received adequate training specific to the operations envisaged, including rescue procedures.

Proper selection of PPE for work at height involves both a wide range of criteria that must be considered to ensure the highest degree of safety for worker, as well as theoretical and practical training of users.

PPE for work at height is used in both surface mining during maintenance of heavy transport vehicles such as loaders, trucks, etc., as well as underground mining.

Depending on your workplace systems can be used to limit the fall (consisting of waist belt / complex + connection pieces + contact mode + anchorage point) or to fall arrest systems (consisting of safety harness + connection piece + sliding fall arrester on flexible anchorage line + anchorage point).

If gassy mines, personal protective equipment exposed to shock of, namely those which are likely to be subjected to impact during use (fall stop) should not be made of aluminum, magnesium , titanium or other alloys contain quantities of these materials where in case of shock the friction could spark and is likely to ignite combustible gas mixtures.

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