

## **ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT SYSTEMS FOR UNDERGROUND MINING**

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### **ABSTRACT**

The serious problems of contaminants and environment impacts produced by human action in the subsurface (air, groundwater and rock in interaction with human activities), particularly in underground mines, require an integrated approach in terms of specific rules, laws and management systems in the domain of Occupational Safety and Health.

As the ISO 14001 standard is mostly directed for the prevention and control of environmental commitments at the Earth surface, it does not deal with environmental problems in the subsurface environment, although its extended range would be highly regarded for this particular application.

Under these trends for the extension of standards to underground mines important aspects have to be considered besides the minimization of environmental impacts, namely in terms of improving efficiency and cost reduction. These requirements consider the economic feasibility of alternatives or correctives actions to use, as a very important goal in engineering projects.

The integral management system known as EHSMS (Environmental, Health and Safety Management System) may provide good working conditions for human work in subsurface environment, minimizing any negative impacts from mining activity and favorable contributions to improve local community life.

The main components of this system are depicted in the following diagram and will be detailed in the article.

### **1. PROBLEMS OF CONTAMINANTS AND ENVIRONMENT IMPACTS PRODUCED BY HUMAN ACTION IN THE SUBSURFACE MINES**

#### **1.1. Underground environment system**

Of similar to the global or exterior environment, the underground environment, the underground environment is corporate for the not biological (air of underground atmosphere, groundwater and rock mass) and biological (virus, bacteria, mainly for human) components (fig. 1), it enters the components of the underground environment

exists a interaction and relation, thus, any alteration of the natural conditions of these components causes environmental impacts being able to put in risk the human life.

The underground environment constitutes part of the global or exterior environment, not being isolated or off of the ecosystem.

### 1.2. Interaction to subsurface environment components

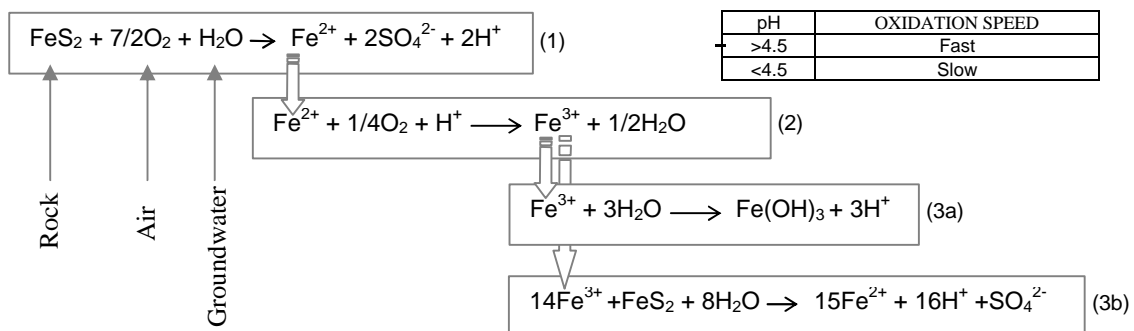
In underground environment is necessary to consider the main management aspects: subsurface atmosphere, groundwater and rock mass, the ones that interact between them, with the man and ecosystem of its scope of share (fig. 2).

The interaction to the components of the underground environment can be expressed of distinct forms, as for example in table 1.

Table 1 – Human action, interaction to subsurface environment components, negative impacts and effects

Human action	Environment				Effect
	Interaction components			Impact	
	Underground atmosphere	Groundwater	Rock mass		
Underground opening	O <sub>2</sub>	H <sub>2</sub> O	Pyrite	Acid drainage	Human and /or ecosystem
	O <sub>2</sub>	Flow	Instability	Fall of rocks and subsidence	
	Density, temperature	Temperature	Absorption and reflection	Noise disturbance and health affect	
	Flow, temperature	Flow, thermal	Geothermal degree	Uncomforted	
	O <sub>2</sub>	H <sub>2</sub> O	CH <sub>4</sub>	Explosion and fire	
	Flow	Flow	SiO <sub>2</sub>	Dust heath affect	

One typical example for interaction to subsurface environment components it is the process of the formation of the acid drainage, generated for the share of the underground opening by *human action* who allows the air circulation, of the groundwater action and chemical reactions with the displayed rock mass, express by the following equations:



### **1.3. Human actions in the subsurface mines and environment impacts**

In the majority of the producing mineral countries, the mines that they are use the underground method between 80% 90% and by means of open pit method between 10% 20% (Llanque, O; Navarro, V.F., et al., 1999). The underground mining is the sector with directly busy human personal greater (López Jimeno, C. 1989).

For the evaluation of the environment impact by the underground mineral exploitation process, it is very important to identify to the sources of impact or environment pollution, which have relation with the cycle of life of this productive stages.

The cycle of life of mining exploitation or underground excavations with explosive have four general stages: drilling, blasting, support, mucking and transport. Each stage generated environmental alterations in underground atmosphere, in groundwater and in rock mass (fig. 3).

The underground mining activities produce the environment emanations that vary since the rejected rubble and tailings deposition, alteration of the land, the dust and the noise and until the use and pollution of the water. In the case of that is not adequately controlled, some of these alterations can adversely afectar the health and the subsistence of the vulnerable groups and the biodiversity of the area of influence of the operations of mining.

The organization shall ensure that the aspects related to these significant impacts are considered in setting its environmental objectives. The significant environmental impacts by human action in the subsurface environment are related to the alteration of the natural conditions and the interaction of air in the underground atmosphere, groundwater, rock mass and the same human.

The key for the mitigação of the environment impact is of adjustment the appropriate standards and control. All the projects of the mining have to agree to the social and environment laws that help to assure of mining operations are undertaken in a responsible way.

## **2. APPLICATION TO ENVIRONMENTAL MANGMENET SYSTEM (EMS/ISO 14001) OF SUBSURFACE ENVIRONMENT**

### **2.1. ISO 14001 standard application for subsurface environment**

The environmental problems occur the daily in the underground works, provoke damages to the man and the environment, demonstrating that alone the application of the rules of law is not enough to prevent or to reduce this serious problem, therefore exist a great necessity to look proactive procedures. Norm ISO 14000 by means of 14001 necessarily considers this procedure (proactive) defying to organization to characterize its environment aspects, to establish its proper goals and objectives, to commit themselves to apply effective and trustworthy processes a constant improvement and to make that the employees and directors practice a system of perception, illustration and shared responsibility, where the fulfillment of the rules of law is more than an element to consider .

ISO 14001 was prepared for the application in organizations of any type and size and to adjust it diverse geographic, social and cultural conditions, exactly that the technology does not constitute requirements in no part of the norm. The only technological requirement is the obligation to consider the use of processes, practical, material or products that they prevent, they reduce or they control the pollution, or can includes recycled, treatment, changes in the process, mechanisms of control, efficient use of resources and substitution of materials (Cascio, J. et al., 1996). Thus, the application of norm ISO 14001 in the management of the underground environment is considered highly positive, considering the rules of law as an element in compliance with the standards of quality of the underground environment (fig. 4).

As an additional aspect, ISO 14001, it considers that the potential benefits of the environmental contamination prevention, include the impact reduction, improved efficiency and reduction of costs, compelling to the employee who when carrying through the audits looks the evidence that these options had been considered still that the chosen solution allows to control the contamination. This petition contemplates the aspect of economic viability of the alternatives of the corrective measures to use, being this important question very in all project of engineering.

## **2.2. Strategical management of subsurface mining environment with ISO 14001**

When a mining company decides to get the certification of norm ISO 14001 can follow a route illustrated in fig. 6 that they show the sequence of shares to carry through for the application of the EMS (Environment Management System), that understands 5 main sections with a total of 17 elements (fig. 5).

It is not recommendable to elaborate a very complicated procedure, is convenient to approach alone what it is related with the intention of the norm. A functional procedure can be:

- To assure the contribution of all the responsible parts of the system. The direction of the organization must foment the total participation of the workers related with the process.
- Simplify the process recommended for the participants with method of successive reduction until obtaining to differentiate between subjects of formation and operational subjects.
- To put in circulation the process with character provisory and time allowed for producing evidence and asking for the opinion of the participants, whose resulted to eliminate or to increase either wen is necessary. Soon of this period to officialize the document and to revise in periodic form to guarantee the continuous improvement.

Elements of the initial levels are most critical of the system that serve of support the superiors, in level 1 it is the element base that is the commitment of the top management and the environmental politics, in level 2 is the environmental objectives and goals, in level 3 the program of environment control integrated by the processes, practical, procedures and responsibility lines. A fed important information to the process of administrative revision is the one that comes from auditors EMS that level

4 understands. The end of this auditors is to assure that the EMS functions as it is waited.

The effectiveness and advances obtained for the EMS are evaluated periodically by means of the located administrative revision in level 5. In the last level it is the final goal that is the final objective that is to reach a constant improvement with the end to assure that the organization fulfills of consistent and trustworthy form its environment obligations and of protection.

### **3. ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT SYSTEM IN SUBSURFACE ENVIRONMENT**

#### **3.1. Environment, health and safety management system in underground environment**

The Occupational Health and Safety Management System OHSMS is conformed basically by: politics; planning; implementation; checking and correction (Cook, A., 2001); also of character cyclical and improvement it continues (fig. 6). The OHSMS allows to an administration of the health and occupational safety guard (OHS) integrated in the structure of enterprise management and to get conscience and responsibility for the OHS, to carry through the measurements of the performance of the system in designed form, to use process of appropriate administrative audits, to adopt a continuous process of improvement and to reduce accidents, damages and costs.

The Health and Safety Management System EHSMS, allows to look for to assure the good health and safety in the work of the staff, to minimize any adverse impact that its activities can cause to the environment and contribute positively for the life of the local community (Maclean, R. et al, 2000).

O Environmental Management System SEM/ISSO 14001 have similar characteristics to OHSMS as in the process as in the structure, therefore a system of management integrated of management of the environment, health and security EHSMS results with four main aspects: politics of the EHS; planning; implementation and operations and finally corrective checking and measures; composition for 10 elements.

One is about an integrated system of environment management system EMS (Environment Management System) and the health and occupational safety management system OHSMS (Occupation Health and Safety Management System) is called EHSMS it is a cyclical process and of continuous improvement for an efficient environment and health protection (fig.7). This integrated system in general terms have four main aspects: EHS policy; planning; implementation and operations and finally checking and corrective action; whose composition is 10 elements.

The stage SHEMS policy of a mining company it must be to assure the good health and safety in the workers, to minimise any adverse impact that its activities can cause to the environment and contribute positively for the community.

The stage of the planing is composed for: risk assessment, laws and norms, operational program, objectives and goals; identification of regulations applicable laws and norms and definition of the program.

The stage of implementation and operations composed for: to define the structure and responsibilities; qualification and to create conscience of the staff; communication; documentation of the EHSMS and control; operational and plain control of reply the emergencies.

Finally the part of the checking and corrective actions composed for: measurements and checking; comparison of results of measurements and with the designed one; correction and prevention; records; internal and external audits and management revision.

### 3.2. Importance of the EHSMS policies

The politics of the EHSMS of a mining company is to search to assure the health and safety in the workers, to minimise any adverse impact that its activities can cause to the environment and contribute positively for the life of the local community.

Table 2 – Policies of te EHSMS for underground mining

Environment	Health and safety
<ul style="list-style-type: none"> <li>▪ To keep better practical one of the system of ambient management.</li> <li>▪ To operate in an environment responsible way.</li> <li>▪ The checking and control and continuous effort in the minimisation of the impact of its operations in the natural environment;</li> <li>▪ To assure conformity in the fulfilment of all the rules of law;</li> <li>▪ The efficient raw material Use;</li> <li>▪ To keep plain of emergency before possible ambient risks;</li> <li>▪ To assure that all the employees and staff of companies contractors have ambient conscience;</li> <li>▪ To include environmental protection for new developments;</li> <li>▪ To include the effective communication on the environment management to community</li> </ul>	<ul style="list-style-type: none"> <li>▪ Believes that all the damages and accidents are prevented.</li> <li>▪ The index of professional health and safety equally or better to standards.</li> <li>▪ The health and safety management consonant the rules of law and adopt the common system for its proper staff and of the contractors.</li> <li>▪ The system will have consider the danger and risk analysis, information and qualification for goal to eliminate damages to health, illnesses or losses.</li> <li>▪ The ability in professional health and safety is equally or so important how much other abilities of work.</li> <li>▪ The shunting lines to the standards of professional health and safety in the operational process are unacceptable.</li> <li>▪ The personal is responsible for its proper safety and of that they work next it.</li> </ul>

### 3.3. EHS departament in underground mining company

The EHS department must be located of had been that it has so equal the necessary importance that other departments and allows an efficient management enclosing since top levels until inferiors. The structure of organization of the company can vary

wants in the structure wants in the elements as they are of support to the presidency or general manager, the management of line and the employees (fig. 8).

The environment, health and safety responsibility must be distributed since top levels until the employees, who will allow to provide a regular feedback to the managers and used in relation to the fulfillment of the organization of the EHSMS to obtain its objectives and goals and the established with the policies.

#### **4. CONCLUSIONS**

The underground environment constitutes part of ecosystem global, with its 4 typical environmental components: air of the underground atmosphere, groundwater, rock mass and the proper man . The human is the more important environmental component , that with its shares of exploitation of the subsurface resources it causes alteration of the natural conditions producing negative environmental impacts, risking its proper life and its health.

The proposal of application of Environmental Management System ISSO 14001/SEM and Environmental, Health and Safety Management System EHSMS at subsurface environment, they are very important management joins in solutions to be used for a sustainable development and management of the subsurface.

#### **5. BIBLIOGRAPHY**

CASCIO, J., WOODSIDE G., and PHILIP, M., (1996), “*Guide ISO 14000*” McGraw Hill, Sidney Australia.

COOK, A. P., AND VAN DER MERWE, J. N., (2000), “*Design, Construction and Testing of Underground Seals*”, Final project Report, Safety in Mines Research Advisory Committee SIMRAC, Shout Africa.

LÓPEZ JIMENO, C., *et al.*, (1989), “*Manual de restauración de terrenos y evaluación de impactos ambientales en minería*”. ITGE, Madrid, España.

LLANQUE, O. E NAVARRO TORRES, V. F. *et al.*, (1999). “*Explotación Subterránea- conceptos y casos prácticos*”. IIMP Lima, Peru.

MACLEAN RICHARD, SUGAR WILLIAM, (2000), “*EH&S Management Systems: Easy to Understand, Difficult to Successfully Implement*” Anheuser-Busch Companies, Inc., St. Louis, Missouri, US.

MARTIN, RAYMOND, (1998), “*ISO 14001 Guidance Manual*” National Center for Environmental Decision-Making Research NCEDR, University of Tennessee.

NAVARRO TORRES, V. F., (2003), “*Underground Environmental Engineering and its Applications to Portuguese and Peruvians Mines*”, Ph.D. Thesis , IST Technical University of Lisbon.