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PROPOSAL TO IMPROVE SAFETY SIGNALING IN THE DETONATION OF ROCKS AT THE CATOCA MINE

Winne Tumba
Department of Technologies and Engineering, Industrial Production Engineering Course, Higher Polytechnic Institute of Technology and Science, Luanda

Dialexis Molina
Department of Technologies and Engineering, Industrial Production Engineering Course, Higher Polytechnic Institute of Technology and Science, Luanda

Salomé Filas
Department of Technologies and Engineering, Industrial Production Engineering Course, Higher Polytechnic Institute of Technology and Science, Luanda

Abstract: This research illustrates the steps in the process of improving safety signs, to reduce the risk of accidents in the rock blasting activity at Sociedade Mineira de Catoca, located in the province of Lunda Sul. This study was carried out from August to November 2019, where respondents were selected based on stratified random sampling. Of the 28 questionnaires applied, 18 were returned (by employees from the Occupational Safety areas - 33.3%, Explosives Factory - 22.3%, Environment - 11.1% and Drilling - 33.3%) and used to the study. Descriptive and triangulation analysis were used to determine the relationship between the variables. The results of the study demonstrate that the safety signaling suffers from improvements, as its state of conservation is reasonable and, consequently, shows unsafe conditions in the activities carried out in the different areas. Therefore, with the challenge of implementing the proposal under study, according to experts, the state of conservation of the signs would improve by 70%, providing a reduction in occupational accidents and an increase in productivity.
Keywords: Mining, Risk of accidents, Safety signs.

INTRODUCTION

The mining sector in Angola is part of the strategic economic domains (General Budget of the State, OGE, 2019), but this sector is one of the most dangerous in the world (International Labor Organization, ILO). Mining activities, specifically in rock blasting operations, have a high probability of generating human and material damages, as people involved in these activities are exposed to various physical, chemical, ergonomic and accident risk factors (Souza; Barros; Filgueiras, 2017).).

This fact makes matters related to safety in the area need more attention, striving to adopt safer procedures that reduce the risk of accidents and contribute to the improvement of working conditions and quality of life for workers.

ISO 45001 (2018) defines HSST (Hygiene, Health and Safety at Work) as factors that affect the safety and health of the employee and third parties in an organization. Because employees are the main asset of any organization, Miguel (2014) states that efforts must be made to prevent and reduce the risk of accidents at work, personal injuries and/or occupational diseases, ensuring greater safety at work. through a culture of safety. In this perspective, Moreira (2010, p. 27), defines work accidents as a negative event that occurs in the place and time of work, producing, directly or indirectly, bodily injury, functional disturbance or illness that results in a reduction in the capacity for work or gain or death. According to the ILO, 2.3 million people die every year as a result of work accidents or occupational diseases, and 15.2% of these deaths are due to accidents at work. Furthermore, the ILO declares that the culture of a safe and healthy working environment must be respected at all levels, that governing bodies, employers and workers must ensure it, through rights and duties, and it proposes accountability to the principle of prevention.

Due to the handling of the elements used and unsanitary environmental conditions resulting from rock blasting activities, it is necessary to adopt preventive measures as ways to mitigate work accidents. According to Moreira (2010) and Gevirtz (1994), preventive measures involve raising workers' awareness, strict compliance with the safety standards established by the company and the use of adequate signage, complementing the security system. In the same way as the stimulating questions about mining exploration (specifically, rock blasting) in recent times, this study proposes to investigate

safety signaling as one of the ways to mitigate the risks of accidents at work in the activity of blasting rocks in the mine of Catoca from the understanding of employees and measurements with appropriate instruments.

According to Murta (2010), when protective equipment alone is not enough to minimize dangerous situations, it is essential to use safety signs with a low level of safety, as it is a complement to warn and guide both employees and employees. third parties on how to proceed in certain situations.

Executive Decree No. 128/04 of 23 November, approved by the Constitution of the Republic of Angola, says that all dangerous situations must be signaled in order to alert workers and third parties of the imminence of an incident and the urgent need to act determined manner whenever risks cannot be avoided or restricted through the use of protective methods.

Such signs must be placed in visible places, in order to attract the attention of those present, be clear and removed immediately as soon as the situation that justified them no longer exists.

As Sociedade Mineira do CATOCA is an Angolan company engaged in prospecting, exploring, recovering and marketing diamonds, focusing on continuous process improvement, innovation and technological adequacy in the mine, the practice of signaling must be done from an engineering project at an executive level and, after implementing the elements mentioned in the project, control of their conservation must be carried out.

Archer (1965), Calori (2007) and Gibson (2009) proposed designer methodologies that were used for the analysis and synthesis of the methods used in signage projects. It started with the studies of methodological convergence model with the objective of identifying points of convergence and divergence between them and, from this information, propose a new process of safety signaling.

The improvement process to be presented, has phases based on the systematic method of designer, however, the analytical phase of this method does not present a detailed analysis of the zone for the survey of the characteristics of the existing safety signaling. In this method, only the information collected in the briefing is processed, and the major disadvantage of the method lies in the quantification and quality of the data collected, since an inspection is not carried out at the place under study. Typically, this is applied to projects from scratch. Unlike the systematic method, the other methods do not present the briefing step. The Calori method is based only on the schematic design of the existing signage through document analysis, which would make it impossible to detect any anomaly or non-compliance that was not documented. The first phase of the Gibson method, on the other hand, would not suit the research because it is only a project, since the first phase of the proposal requires a schedule for the survey and evaluation of all information concerning the existing signage. For these reasons, a new model was structured that allows to mirror in a simplified way the crucial points of the process, as well as to evaluate the performance measures.

MATERIALS AND METHODS

TECHNICAL PROCEDURES AND DESCRIPTION OF THE RESEARCH SAMPLE

The project adhered as technical procedures, the bibliographic survey and the case study. Thus, data was collected from the participants of Sociedade Mineira de Catoca. The study was conducted on a stratified random sample where employees were selected according to categories and

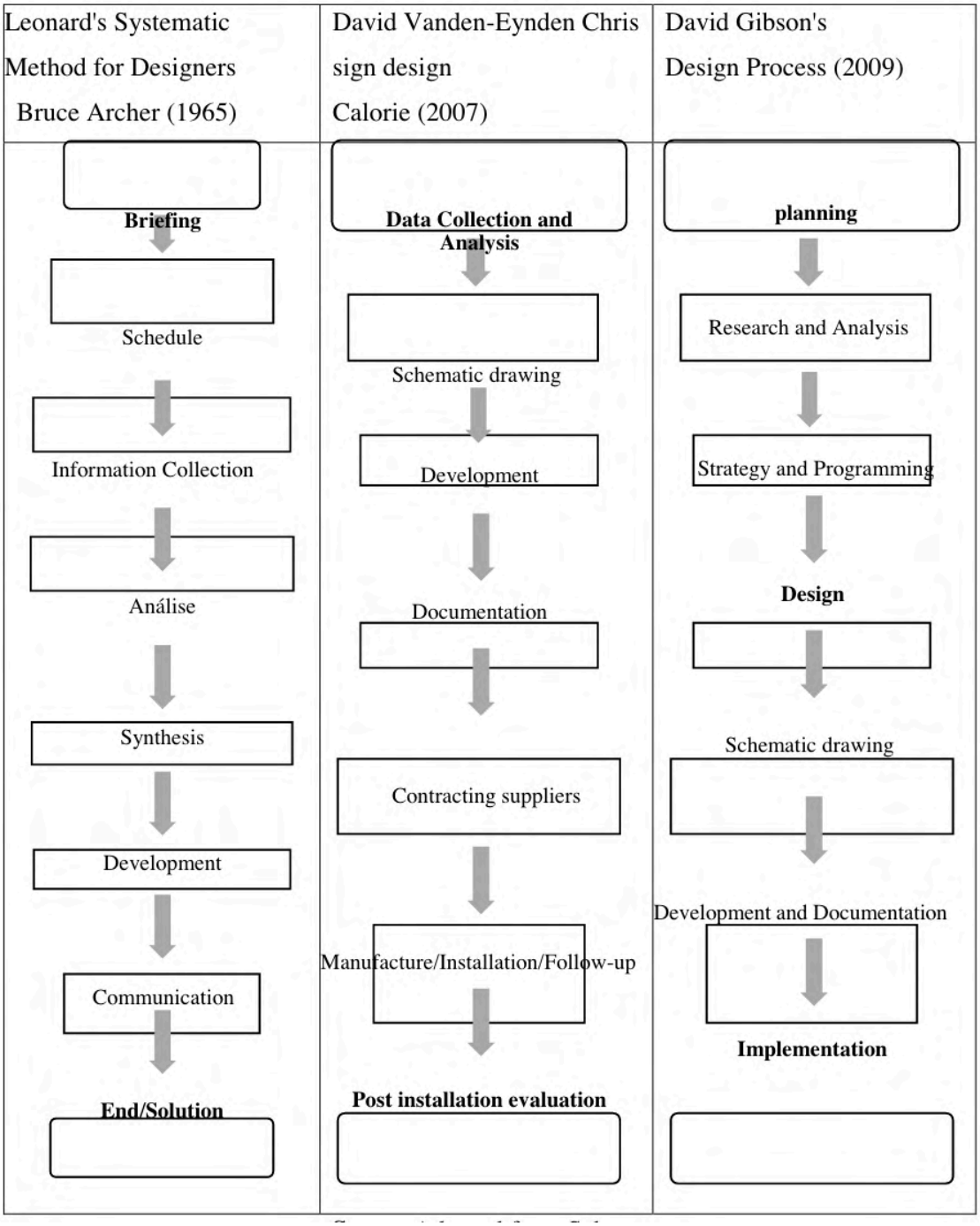


Table 1. Illustration of signaling methodology flowcharts.

Source: Adapted from Scherer.

sections (employees with technical skills or experience in the environment, work safety, drills and explosives). As ways to select each representative element, a simple random sample was used where all employees had the same probability of being chosen to be questioned.

In accordance with the ethics of the research, with a total population of 76 workers, however, due to the work regime (relay/shifts) the selected sample was 28 employees. A stratified random sample was used where employees were divided into categories according to sections. As ways to select each representative element, a simple random sample was used where all employees had the same probability of being chosen to be questioned. Data were collected over a period of 3 months. The demographic details of respondents are shown in Table 1.

RESULTS AND DISCUSSIONS

During the participatory observations in the mining society of Catoca, it was found that the activity of detonation with explosives is an activity with a high risk of accidents and, in turn, requires greater attention and care due to the negative causes that it can generate. Through the application of a survey to workers in the area, it was possible to draw existing conclusions about it.

1) Classification of risks in the work environment:

Physical, chemical and ergonomic risks

For the classification of risks on the work fronts, it was found that the ergonomic risks are reduced, but the physical and chemical ones have a greater impact due to the handling of expulsive emulsion and its accessories, as well as the disposition of the work fields (mine) and manipulated equipment.

2) Accidents in the rock blasting operation

According to the information collected, 47% of those surveyed were victims of accidents (falling to the same level) in the stages of the rock blasting activity, namely in the manufacture of the emulsion-explosive, loading of wells, assembly of the blasting network and in the inspection of detonating

Factors		Features	Population	Sample	Percentage
Gender		Male	27	17	60,7%
		Female	1	1	3,5
Age		25-35	8	8	28,5%
		35-45	10	5	17,8
		45-56	10	4	14,3
Academic degree		Elementary school	10	2	7,1
		High school	6	5	17,8
		Bachelor	9	8	28,5%
		Master	3	3	10,7
Profession		Engineer	12		
		Designer	2		
		Technicians	7		
		Assistants	7		

Table 1. Demographics of respondents.

Source: Authors (2019).

blocks. as shown in Graph 1. Mostly, these accidents are caused by slippery floors, uneven floors, non-use of personal protective equipment, lack of safety signs and human errors (behavioral deviations).

As ways to reduce accidents, respondents point to the rigorous use of personal protective equipment, implementation of safety signs and communication between interconnected sectors as options for prior solutions.

Due to the fact that the main objective of the activity is to break certain fields, it is crucial to implement safety procedures where safety signs must be looked at carefully.

For SMC, the following procedures were adopted:

- During the dismantling of gneiss and ore using the explosive method, a 24-hour notice is given to all areas affected by the mine.

- One hour before the activation of the initiation tubes (detonation) the safety signs are collected in the blasting area and the interdiction of the routes and evacuation of personnel who are positioned within the blasting action radius.

- Long and continuous activation (15 minutes) before starting the assembly of the detonation mesh;

- Two long 40 second beeps with a 20 second interval 5 min before detonation;

- Detonation confirmation.

- Finally, an inspection of the detonated blocks is carried out as a way of verifying the efficiency of the explosion and afterwards, a sign is placed to authorize the collection of ore and release of the roads.

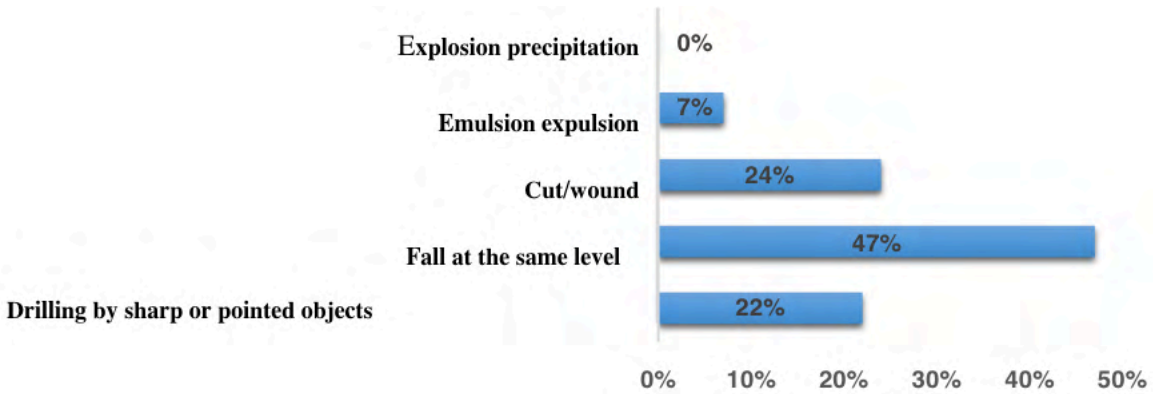
Due to the lack of maintenance of the signs, reduction of personnel who produce the signs and the current state of some signs, it is necessary to create improvement strategies since this activity is of high risk for workers and neighborhood and has a strong impact on the environment.

PROCESS OF IMPROVING SAFETY SIGNALING IN ROCK BLASTING ACTIVITY

The improvement process consists of 3 phases, where its elaboration is flexible, as it presents the possibility of interconnection between the phases as shown in Figure 2.

ANALYTICAL PHASE

At this stage, all necessary information is collected regarding the company's needs, the problem to be solved, the limits and conditions of the project, based on the briefing and the survey carried out in the area under study.



Graph 1: Types of accidents occurred in the rock blasting activity at Sociedade Mineira de Catoca.

Source: Author (2019).

Figure 1: Signaling Demonstration.

Source: Author (2019).

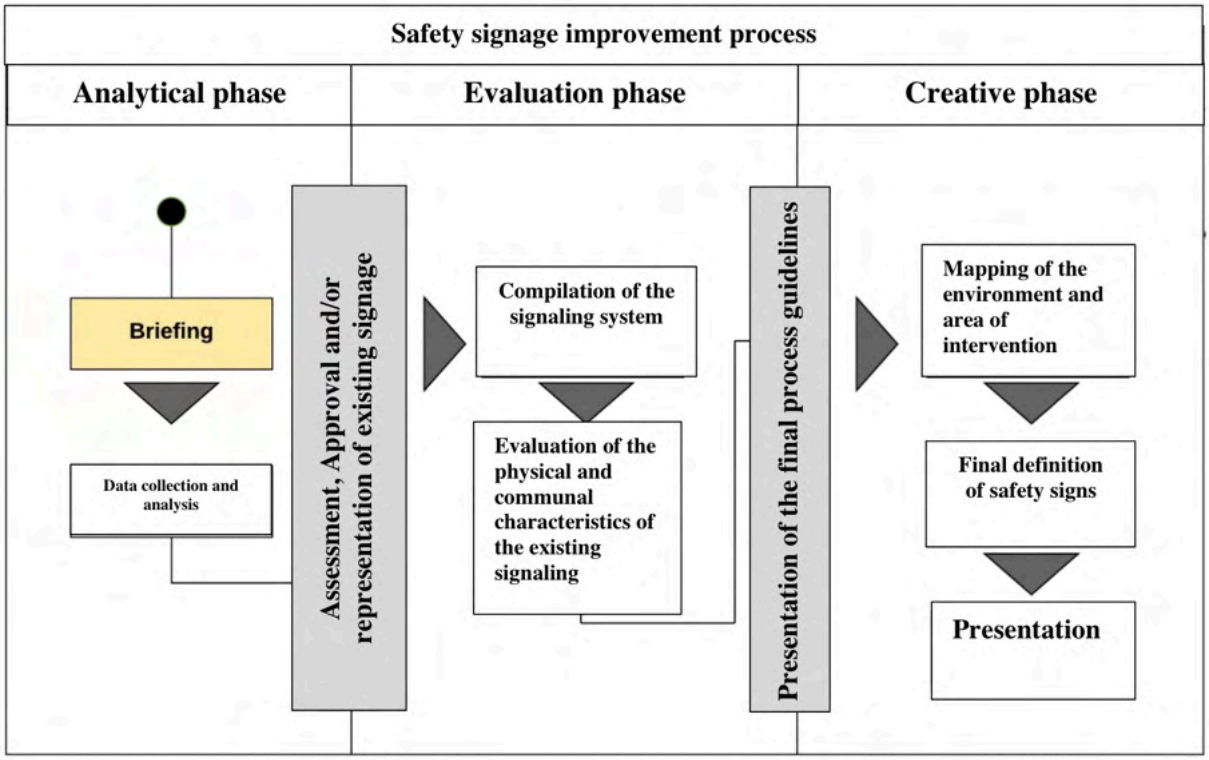


Figure 2: Proposal for the safety signaling improvement process.

Source: Authors (2019)

1. Briefing

The briefing is the first step to be taken in which there is interaction between the designer, professionals and users as a way to enlighten them about what will be done.

This must be created and exposed by the designer or head of work safety. After approval by the head of the sector, it is exposed to directors and members of related areas.

2. Data Collection and Analysis

The data collection must be done by the designer during the activities. The latter carries out a survey of the characteristics of the area and the existing signage and subsequently the collected information is analyzed.

a) Survey of the characteristics of the path Explosives factory - Zone to be detonated

For this stage, the designer and his team must record the route, direction, location and type of pavement that surrounds the area.

b) Survey of the characteristics of the existing signage

At this stage, two specific sources must be taken into account: security inspection and consultation of existing signage records and executive projects. The team of designers must define different strategic points of visualization of the signage (fixed points and during a route) in order to observe, annotate and make photographic records of the existing signage. To this end, you must choose observation points and capture the flow of activities for the collection of data such as: the state of conservation of the signage, dimensioning, positioning, reflectivity and details of the pictogram, through safety inspection. Subsequently, the existing registers and executive projects for signaling are consulted.

EVALUATION PHASE

Based on the information that was collected in the previous phase, the field worksheet (APR) must be filled out, so that it can later be evaluated regarding the existing safety signaling system according to the governing legislation.

1. Compilation of existing signaling data

After collecting data in the field, the field worksheet is filled in with data on the current state of the existing signage according to the activity, stage, hazard/risk and causes, in order to organize and document the information for the detailed assessment of points of interest.

2. Evaluation of the physical and communicational characteristics of the existing signage

An evaluation of the signage is carried out, specifically of the plates and details of the pictogram (letter size, color and reflectivity) from the data collected in the previous step to know if they are in accordance with the purpose of being selected to decide. which signaling remains and which needs to be implemented, thus moving on to the next phase.

CREATIVE PHASE

The creativity phase comprises analysis, synthesis and development in a process that allows feedback based on the briefing and performance evaluation of the sign.

1. Geographic mapping

The image must be captured at the desired location by means of a satellite (Google Earth) or drone in order to have a global view of the area under study. In this step, the location, geographic coordinates, as well as the distance to almost performed the image capture must also be described.

Figure 3: Mine Overview Source.

Source: Google Earth (2019).

Figure 4: Perimeter under study.

Source: Google Earth (2019).

Figure 5: Safety signs on the Explosives Factory section – Detonation zone.

Source: Google Earth (2019).

2. Area definition

To define the area, you must demonstrate the perimeter that is intended to implement the process through topographic (obtained by an altimetric survey) and geographic (acquired by Google Earth) illustrations, where the safety signaling system must be exposed. existing.

3. Final definition of safety signaling elements

In this step, the final allocation of the elements of the safety signaling system that must be presented in the proposal is made.

VALIDATION OF THE SAFETY SIGNALING IMPROVEMENT PROCESS

The Delphi method was used with the aim of obtaining qualitative information from specialists, work safety technicians and designers questioned, regarding the vision of improving the safety signaling system created. Respondents were asked, given the most important changes that take place in the integrity of workers, to estimate some points, taking into account the results of the first survey. For this, an anonymous survey was prepared consisting of 2 questions, as ways to obtain the following results:

1. Risk reduction and worker safety?

If the improvement process were implemented, the risk factors would reduce to 70% in relation to the percentage linked to all levels that cause damage, and service locations would become increasingly safer.

2. What improvements would the process created for the company bring?

- Better identification of adverse risks inherent to the activity carried out;
- Greater security for signage users;
- Reduction of accident costs;
- Information worker ammunition and prevention tools to successfully mitigate any type of accident or incident.

FINAL CONSIDERATIONS

During the data collection period, due to the confidentiality of some processes, it generated insecurity in most employees. As a result, this could have an effect on providing accurate information because they are likely to assume that management would assess their commitment to the organization from the information provided. Future research can therefore explore the same variables in the organization as ways to improve results. The assessment of the report by safety, environmental and mining experts made the results more impactful.

It was also noted that although many employees have already suffered some type of accident in the mine, mostly due to human error, they still neglect the existing signage, practicing unsafe acts, such as smoking in the blasting perimeter. During the research it was found that many of the employees are unaware of the existence of the company's signaling plan.

Therefore, respecting safety signs, keeping them in good repair, prioritizing pre-established maintenance, training employees in safety procedures and making a permanent occupational safety technician to inspect the blasting area contributes to the reduction of the risk of occupational accidents in the rock blasting activity.

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