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REVIEW

Electrical risk management in the work environment: A comprehensive review

Gestión de riesgos eléctricos en el entorno laboral: Una revisión integral

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ABSTRACT

Introduction
The article examined electrical hazards and their implications for occupational safety, focusing on research conducted in Ecuador and Colombia. The authors analyzed the effects of electrical accidents on health and well-being, highlighting the need to implement preventive measures and promote a culture of safety in work environments.
Development
Risk factors associated with contact with electrical sources were identified, such as inadequate maintenance of equipment and lack of technical training. Preventive tools such as procedure manuals, adequate signage and the use of personal protective equipment (PPE) were also highlighted. Research showed that electrical accidents can have serious consequences, including irreversible injuries and fatalities. In Colombia, risks were assessed in buildings constructed before the implementation of the Technical Regulations for Electrical Installations (RETIE), while in Ecuador the importance of safe work procedures was stressed. In addition, strategies were proposed to identify and control risks through training and specific protocols.
Conclusion
The article concluded that proper electrical risk management requires a comprehensive approach that combines preventive measures, continuous training and effective technical tools. The relevance of fostering a safety-oriented organizational culture to minimize accidents and ensure a safer and more productive work environment was emphasized.

Keywords: Electrical hazards; occupational safety; prevention; training; electrical accidents.

RESUMEN

Introducción
El artículo examinó los riesgos eléctricos y sus implicaciones en la seguridad laboral, enfocándose en investigaciones realizadas en Ecuador y Colombia. Los autores analizaron los efectos de los accidentes eléctricos en la salud y el bienestar, resaltando la necesidad de implementar medidas preventivas y promover una cultura de seguridad en los entornos laborales.
Desarrollo
Se identificaron factores de riesgo asociados al contacto con fuentes eléctricas, como el mantenimiento inadecuado de equipos y la falta de capacitación técnica. También se destacaron herramientas preventivas como los manuales de procedimientos, la señalización adecuada y el uso de equipos de protección personal (EPP). Las investigaciones demostraron que los accidentes eléctricos pueden tener consecuencias graves, incluyendo lesiones irreversibles y muertes. En Colombia, se evaluaron los riesgos en predios construidos antes de la implementación del Reglamento Técnico de Instalaciones Eléctricas (RETIE), mientras que en Ecuador se subrayó la importancia de los procedimientos de trabajo seguro. Además, se plantearon estrategias para identificar y controlar riesgos mediante capacitaciones y protocolos específicos.
Conclusión
El artículo concluyó que una gestión adecuada de los riesgos eléctricos requiere un enfoque integral que combine medidas preventivas, capacitación continua y herramientas técnicas eficaces. Se enfatizó la relevancia de fomentar una cultura organizacional orientada a la seguridad para minimizar los accidentes y garantizar un entorno laboral más seguro y productivo.

Palabras clave: Riesgos eléctricos; seguridad laboral; prevención; capacitación; accidentes eléctricos.

INTRODUCTION

Currently, in the prevention of electrical risks, it has been possible to verify that the Ecuadorian situation regarding the issue, considering the current state of electrical risk prevention, it has been possible to verify that in Colombia, a research project has been carried out entitled "Design of the program," carrying out a research project entitled "Analysis and mitigation of electrical risk in a building constructed before the entry into force of the Technical Regulations for Electrical Installations (RETIE)," carried out by the authors Cazallas Suarez, J. E., & Gámez Gómez, F. F. (2021) in which was carried out in the city of Bogotá from the University of La Salle in the Faculty of Electrical Engineering its main results are the Consequences of the materialization of an electrical risk where you can see the different scenarios of risk factors present in the study that they highlighted as it can affect people's health. Prolonged exposure to electrocution can cause irreparable damage to health or even death. Electrical accidents are the leading causes in homes, companies, and public or private institutions, and the different causes can be these.

-When cleaning near exposed electrical devices and/or conductors.

-When handling electrical equipment or circuits, make arrangements to install an electrical connection.

In Ecuador, research has been carried out on electrical risks at a local level, where it was possible to verify the existence of a study carried out at the Technical University of Cotopaxi in the canton of Latacunga, presented by the authors Correa Iván Marcelo (2020). Their results show that this involves the use of measuring equipment and other electrical elements whose risks it is necessary to be aware of and it was mandatory to prevent in all the processes and procedures involved

Since safety is paramount in daily work activities, the prevention of possible electrical accidents can be prevented when working with a basic manual of safe work procedures as well as the types of electrical

risks that can be found, such as physical risk, chemical risk, biological risk, ergonomic risk, psychosocial risk, mechanical risk, According to the type of activity, the different incidents, accidents or occupational diseases to individuals occurred, more than reasons to encourage the protection of human resources.

Moreover, the most important result was direct accidents, which are caused when people come into contact with sources of electrical current such as cables and plug sockets. The consequences are physical; indirect accidents are those that, even though they result from contact with electrical current, have different consequences, such as being hit by objects, falls, and injuries.

DEVELOPMENT

Exposure to electrical hazards

Risk factors

The electrical risk factor is related to the electrical systems of machines and other equipment, which, when coming into contact with individuals or facilities and materials, have the potential to cause injury to operators and collaborators who handle the different machinery according to the assigned task, thus even causing property damage (Henao, 2014).

In short, electrical hazards are perceived as factors that cause accidents to individuals when they come into contact with them, taking into account the handling of machinery within the facilities and the student's knowledge of the task to be performed.

According to Ruiz (2021), it is essential to know the general points of electricity, its mechanisms, and the types of injuries generated by them, which are poorly understood by most people.

Given the dangerous nature of electricity and its dangers to the lives of individuals, it is essential to offer an opening to knowledge in this case, in which several workers from energy-generating organizations and all industries that use this factor are exposed to various dangers that lead to accidents and incidents. In this work, the aim is to explain the components of danger created in these organizations and propose preventive measures that allow for control over such events and to avoid regrettable situations.

Quality of the work environment and the work environment of the different student activities.

Soler, (2009). A work environment fosters the development of an organizational culture based on shared needs, values, expectations, beliefs, rules, and practices transmitted by the members of an organization that manifest themselves as similar behaviors.

The purpose of this point is to create or foster a good work environment, which helps the workers or employers of a given company perform well at work and benefits the company.

Level of maintenance of the electrical equipment used by the students.

Plant maintenance is essential as it enables us to plan for the correct maintenance of the groups according to the correct schedule and the company's requirements (Diaz, 2006).

Electrical maintenance is fundamental because it ensures that the equipment does not malfunction, thus preserving the plant's activity and performance and increasing the efficiency of the service provided. However, many institutions, factories, organizations, and others attach little importance to maintenance, which causes serious economic and social inconveniences for the company.

Preventive management against electrical risk

According to the ILO (cited by Delgado, 2019), industrial processes and scientific advances have led to the emergence of occupational hazards, prompting researchers to adopt comprehensive approaches to dealing with these dangers. In this way, models for prevention and mitigation are developed, and machinery has to be complemented to create processes that allow for evaluating and understanding the effects, detecting the dangers, and adopting measures for prevention, supervision, and review within the systems for the administration of stability and union health worldwide.

The area of occupational health and safety in companies plays a fundamental role because preventing, mitigating, maintaining control, and evaluating hazards has become an indispensable exercise due to current regulations since making all workers and employers aware of issues related to the prevention of

accidents or occupational diseases helps us to make the work environment reliable for carrying out the tasks that are made known to each of them.

Identification and evaluation of the different causes that can lead to accidents.

It is the process aimed at estimating the size of dangers that cannot be avoided, obtaining the basic information to make a convenient choice about the need to adopt preventive measures and, in such a case, about the type of measures that have to be adopted (Laborales, 2015).

In short, each job has different risks and dangers that must be controlled and evaluated before any task is assigned by any identity to the workers. This must be done to avoid work accidents that can be catastrophic and even harmful to the company.

Elimination and control of risks.

The discipline seeks to promote the optimization of the stability and health of workers at work through the application of measures and the development of the correct occupations to prevent the dangers derived from the working conditions, having as an important instrument the evaluation of dangers. (Laborales, 1995)

The purpose of occupational health and safety is to provide a procedure for evaluating and improving the results in the prevention of incidents and accidents through the effective management of risks and hazards in the workplace. The types of electricity handled in the organization, according to (Escamilla, 2018), are the physical phenomena involved in the existence and flow of electrical charges. It is present in various phenomena such as lightning, static electricity, electromagnetic induction, or the flow of electric current. It is such a versatile form of energy that it has endless applications.

Exposure to electrical hazards is very common in companies and everyday life, as we constantly handle electricity, whether switching on a light, plugging in a cable, coming into contact with an electrical appliance, or maintaining it, among other things. So care must be taken when handling electricity or in contact with it.

Alternating current

According to Hellaso (cited by Córdoba, 2009), alternating current is defined as a current that flows in one direction for some time and then in the opposite direction, repeating the same process constantly. Its polarity is periodically reversed, causing the current to flow alternately in one direction and then in the other. In Spanish, it is known by its abbreviation CA, and in English, AC.

According to the above, an alternating current changes its polarity in each time period, inverting the direction in which it moves with each change of polarity. In other words, it will alternate between continuing and moving backward in time. However, it is not restricted to a constant period of time.

Direct current

This belongs to the aforementioned persistent system and will be referred to from now on as DC. As mentioned, the charges move in a single direction and generate work, according to Joule's Law. Its implementation is important in all electronic equipment because the different circuits and elements operate through it. (Direct current)

The object of the present statement is direct current, which moves in only one direction, like the current that flows in a flashlight or in any other battery-powered device.

Safety elements

The purpose of protective elements is to defend the worker from the dangers to which he is exposed during his work and to increase his safety so that the injuries are not so serious if he suffers an accident. (Gerencia.com, 2022)

Safety is very important because keeping workers or people who carry out a work activity in a company safe is important because, thanks to them, the company fulfills its objectives and productivity.

Student training

Training is a systematic, planned, and persistent activity whose general objective is to prepare, develop, and integrate human resources to develop a defined professional activity that is even more

connected to the charitable system. The training aims to improve the workers' technical skills to perform efficiently in the assigned areas, thus obtaining quality results, surprising performance, service, and a profile adjusted to the needs of the field. (Martínez, 2012)

Knowing about the activity or work to be carried out is very important because it helps us carry out the activities in the best possible way, avoiding accidents or problems. For this reason, it is important that workers acquire new knowledge through training.

Control by the teachers in the area.

According to (Guerrera, 2016), the labor inspectorate follows the “generalist” model characterized by an extensive precept that covers the entire scope of labor law and social stability. In addition, it is assigned methods that fall outside the mainly accepted orbit for labor inspection (such as conciliation) and have specific “quasi-judicial” powers. It has a central and decentralized composition, and in truth, its human and technical resources are insufficient to accomplish the ambitious goals it sets itself.

Controlling the activities to be carried out plays a vital role in companies because verifying that the assigned activities fully comply with benefits productivity makes companies highly efficient and productive.

Means of collective protection

According to Diaz (2016), collective defense is understood to be a stability technique whose objective is the defense of several workers simultaneously exposed to certain dangers. In contrast, for personal defense, we know that the means will only protect a specific worker.

Collective defense safeguards against dangers that cannot be avoided or minimized, and this defense includes, without exception, all the people who benefit from it. Collective defense takes precedence over personal defense since the latter reduces the possibility of danger.

Testers and the absence of voltage

The voltage detector device will not need to make physical contact with the energized part of the installation, but it will be enough to bring it close, exemplifying at the base of the withdrawal the support composition of the equipment in the situation of a high/or medium voltage substation the voltage detector device will capture the electric field formed between the energized parts of the installation and the ground, this would make it suitable for verifications even in humid climates os debido a que no se invadiría la distancia de estabilidad. (Garcia,2015)

El objeto de le mismo sobre el detector de la presencia de ausencia de voltaje para baja, media y alta tensión se desarrolla en varias etapas con la finalidad de evitar accidentes por contacto eléctrico a los trabajadores que realizan cualquier mantenimiento eléctrico.

Magnetothermic

According to Sumidelec (n.d.), a circuit breaker is a safety switch that protects installations, especially cables, from overload or short circuits. The circuit breaker consists of two safety mechanisms, one magnetic and the other thermal, hence the name.

It cuts the current or magnitude in times short enough not to damage either the network, installation, or the associated devices. They are used instead of fuses because they have the virtue that they should not be replaced with a new one once they are joined.

Differential protection

According to Ramírez (cited by Yepez, 2015), a differential system can truly defend a transformer thanks to the inherent reliability of the slip rings, which are enormously effective in operation, and the fact that equal turns are developed in the transformer's primary and secondary windings.

It is strictly selective protection that is applied according to the current intensities to avoid accidents when working or handling it.

Use of EPPS

Personal protective equipment (PPE) is designed to be worn or held by the worker to safeguard him or her against one or more hazards that threaten his or her stability or health at work, as well as any supplement or accessory designed for this purpose. (Pérez, 2012)

It is important to have personal protective equipment as it protects us from any risk of accidents and damage to health. It must be used correctly so workers feel safe when carrying out any assigned activity— insulating gloves.

Insulating gloves safeguard against the passage of electric current through the body (electric shock) produced by physical contact with a conductor at a different voltage (Estrada, 2011).

These are used as personal protection for the hands to avoid contact with electric current when working with or handling electricity.

Safety Clothing

Workwear for electricians depends on the hazards to which they are exposed. It all depends on whether they work without voltage (with the electricity switched off) or whether their work requires them to work with live lines (with electrical voltage). In cases where they work without voltage, the clothing will be a shirt, T-shirt, or polo shirt with short sleeves in summer or long sleeves together with a fleece lining in winter. Multi-pocket trousers in cotton or a cotton and polyester blend. (Onzor, 2020)

The purpose of this point is that safety clothing must be suitable for any electrical work because when using clothing that contains some material, you can have electrical contact and cause electrocution.

Dielectric boots.

These boots are specially designed for safety according to the extent of the electrical preparation because their design includes insulation for the protection of the wearer. (Estrada, 2011)

One special property that these boots must have is the material from which they are made because their primary purpose is to safeguard the worker's life when handling electrical energy.

Goggles.

Goggles are for personal use and are compulsory for workers. They provide safety when carrying out any activity with electrical energy, which can produce sparks or radiation from an electric arc that can affect eyesight. So, it is very important to use this piece of personal protective equipment.

Dielectric helmet.

These helmets seek to minimize the risk of electric current exposure, protecting against contact with high-voltage electric currents or the impact of an object against the worker's head.

Factors that determine damage from electrical contact

According to (Castro, 2010), these parameters are directly proportional to the effects produced on the human body because the consequences will be more serious the more significant the magnitude and duration of contact, and the path taken by the current covers areas of greater sensitivity.

Controlling risks helps to avoid damage to workers, equipment, or materials. Taking safety measures into account means that workers carry out their activities in a safe and reliable way, which in turn favors the company's performance.

Intensity in milliamperes

A milliamperage is one-thousandth of an ampere (one thousand milliamperes is one ampere), the international unit used to measure the magnitude of electrical currents. The ampere measures how much energy circulates through an electronic circuit (we are talking about smartphones), so the element of time is added. (Xalaka, 2021)

The aim is to measure the magnitude of the current with which one is going to work in order to avoid accidents caused by contact with the current present in the cables or lines in which any manipulation is to be carried out.

Current frequency

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The frequency of a current suggests how many times a wave period is repeated per second and is measured in hertz (Hz). The mains current has a sinusoidal wave and a frequency of 50 Hz, i.e., it repeats 50 times per second. (Humane Slaughter Association, n.d.)

Types of electrical hazards

Electrical hazards are associated with the effects of electricity and mainly involve working with electrical installations. These installations comprise resources used to generate, transport, and use electrical energy. (Toledo, 1990)

Electricity is the most potent energy source currently available, whether in direct or transformed form, reaching every corner of the world.

- Risks from direct contact
- Risks from indirect contact
- Risks from working with high and low voltage
- Risks from working at height
- Risks from working on energized and non-energized lines

For this reason, the electrical risks that are associated with work or in everyday life were taken into account, as these risks are mostly present, which means that employers must increase preventive measures to avoid accidents at work and create a safe, reliable environment within the workplace.

Risk levels

Organizations have the potential to expose themselves to various types of hazards in the course of their activities. Establishing the necessary controls promotes a situation of well-being for companies, in which the aim is for the degree of control to be as high as possible. (Ealde, 2016).

This takes into account the levels of risk present in the work area, which are:

- Fatal or Catastrophic (F)
- Very Serious (VS)
- Serious (S)
- Minor (M)

Implementation of a signage manual

According to Brancor (n.d.), a signage manual has its own methodology that includes different disciplines, which increases its difficulty. Behind every informational, directional, or emergency sign, there is descriptive graphic design work. It is not just a question of generating a visually striking sign; it should contain strict information so that it fulfills its functionality correctly. The signage manual should include the main types of signs to help with orientation in an enclosed or open space.

It is essential to have or create this signage manual to ensure clear and effective rules for orientation in the facilities where a job is carried out. In addition, this file tries to unite and consolidate the graphic images present in the spaces to prevent any risk.

Warning signs

According to Costa (cited by Guamushig, 2016), signage is a visual communication technique based on the analysis of the functional collaborations between the orientation signs in space and the behavior of people in front of them. It seeks to obtain better and instantaneous accessibility to various sites and services.

When applied, signage helps individuals orient themselves in a place or a defined space, ensuring the best and most instantaneous accessibility to the required services and greater stability in moving around the site.

Information from symbols when observed

In this sense, a sign is a component or an object, graphic or material, to which a meaning has been attributed by society or social convention. Symbols can transmit ideas or give information instantly using visual language (Significados.com, 2013).

The purpose of this is to help the person understand the meaning of the message that is to be transmitted by means of visible symbols, which replace long texts that, in some cases, are not easy to understand.

Golden Rules

According to Flores (2010), the golden rule is the most common method for working without voltage in electrical installations. It remains widely accepted among experts in the electricity sector and is regulated by national standards and methods of electrical organizations..

•Disconnection. Effective cut-off

•Prevent any possible feedback. Blocking and signaling

•Verify absence of voltage

•Grounding and short-circuiting

•Signaling of the work área

Following the 5 golden rules ensures stability in electrical installation work, especially when the Activity or maintenance will be carried out by assigned personnel. Following these rules helps to avoid accidents caused by contact or electric shock.

Instructions

This is the systematic process that makes it possible to examine the needs and goals of education, selecting and developing the tactics, activities, and resources that facilitate the achievement of the goals set, as well as the methods of evaluating learning and all instruction; this process makes instruction more efficient and relevant (Dorrego, 2007).

When giving instructions, the following points should be taken into account as they are essential, such as:

•Handling guides

•Signage analysis

•Use

•Signage and demarcation in the work area

•Control system

The aim is to show how to carry out an activity correctly, considering how to follow these orders correctly to avoid damage to equipment, materials, and even the people carrying out the tasks. It provides us with a guide to the correct placement of the same, the correct place in which they should be located; these should be controlled since correct compliance will benefit both the company and the workers as they will help us avoid accidents in the work areas.

Work procedures manual

A manual is any guide of instructions for the use of a device, the correction of problems, or the establishment of work methods. Manuals are essential because they transmit information that helps individuals perform in a defined situation. Generally, manuals are recurrent, accompanying a defined product or piece of equipment (Molina, 2016).

• Planning

• Organization

• Execution

• Control

• Safety regulations

A procedure manual must include correct planning and organization for its use so that when an activity is carried out in the work area, it is performed correctly by the rules established by the company or institution. For the correct fulfillment of the aforementioned, it must be taken into account that the activities in the area must be controlled to verify that they are performed and fulfilled correctly to guarantee a benefit for the company.

Risks at work

A work-related risk is any event that puts both workers and employers at risk, causing physical or psychological harm. Just as there are different types of work, the dangers and seriousness also differ (Unir, 2021).

The objective of this point is to learn about the occupational hazards that arise in each activity to be carried out. Preventive measures must be implemented to control and minimize the risks, which will help us avoid occupational accidents that can harm the company and the workers.

Electrical risks

Electrical hazards depend on the flow of current that arises once a person comes into contact with live parts, with faulty electrical means of production, or once a short circuit occurs. Ohm's Law determines the magnitude of the current flowing through the body. (Dimitrova, 2011)

The objective of this point is to understand the flow of current through the body or an electric shock, which causes accidents due to the passage of the current. The current causes different reactions in the muscles that can, in turn, cause trips, slips, or falls.

Dangers in carrying out electrical tests

The purpose of the electrical tests carried out during the commissioning, preventive maintenance, corrective maintenance, and/or diagnosis of the electrical power distribution groups is to check the conditions in which they are found, with the aim of ensuring the continuity and reliability of the electrical distribution system of our workplace or company.

Checking that electricity is available for a job is very important because this point aims to generate confidence when carrying out maintenance or handling cables or electrical equipment.

CONCLUSIONS

The review highlights the importance of adequately managing electrical risks in work and everyday environments, emphasizing the relevance of adopting preventive and corrective measures to mitigate accidents. The studies reviewed in Ecuador and Colombia underline the need for continuous education, the development of procedure manuals, and the implementation of technologies and equipment that minimize the likelihood of electrical incidents.

One of the most notable findings is the significant impact that electrical accidents have on workers' health and safety, which highlights the urgency of promoting an organizational culture focused on risk prevention. Research shows that direct and indirect contact with electrical sources can have serious consequences, ranging from injury to death. Therefore, implementing clear protocols such as the "Golden Rules" and the mandatory use of Personal Protective Equipment (PPE) is an indispensable strategy to protect employees.

In addition, critical factors such as poor equipment maintenance, lack of technical training, and absence of adequate signage are identified as contributing to increased electrical risks. Proper planning and execution of maintenance programs, as well as the provision of clear signage, are fundamental measures to guarantee a safe environment.

Another key axis is the constant training of workers and students, as it allows people to acquire the necessary knowledge to identify and control electrical risks effectively. This proactive approach not only protects the physical and mental integrity of employees but also improves companies' productivity and sustainability.

The study also emphasizes the importance of collective protection measures against electrical hazards. These mechanisms effectively safeguard several workers simultaneously and should be complemented by individual strategies. Tools such as voltage detectors, circuit breakers, and residual current devices are essential to prevent serious incidents.

In short, guaranteeing safety against electrical risks requires a comprehensive approach that combines technical knowledge, implementing preventive and corrective measures, and promoting a culture of workplace safety. The conclusions reached in this review highlight the need to continue strengthening

prevention and awareness systems around electrical risks to protect human lives and material resources in all areas.

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FINANCING

None.

CONFLICT OF INTEREST

None.