

Application of NR-10 regulatory as a method of accident prevention in electricity in two companies from Manaus industrial district in Brazil

Carynne Santos da Costa, Fabiana Rocha Pinto, Thiago dos Santos Alves

Academic department, University Center FAMETRO, Manaus -AM, Brazil

Abstract— This paper aims to analyze through field research the effects of Brazilian regulations, where the main focus is on accidents related to work with electricity (NR-10), although NR-10 is a mandatory regulation in Brazil, not all companies are using them as internal control rules, especially those in which external oversight is not as effective, thus comparing one large-sized company with a medium-sized company, the data collected were able to express the main concern of these companies regarding the safety of their employees and the imminence of fines and legal proceedings.

Keywords— Rules, companies, safety, electricity.

I. INTRODUCTION

The use of electricity in Brazil started in the end of nineteenth century, when in 1879, Dom Pedro II inaugurated the first permanent electric lighting installation in the country, at Dom Pedro II Central Station in the city of Rio de Janeiro [12].

Since then, with increasing population, the demand for electricity has been growing exponentially and its use is necessary for the functioning of many processes and products of modern society, making it essential for the social and economic development of the countries, among other purposes.

According to data from the demographic research of 2010, conducted by the [7], 97.8% of the population has access to electricity or services involving the use of electric energy, and this demand is in a continuous process of increase, with high probability of occupational accidents occurring in electrical installations, [11] highlights that the occurrence of fatal accidents involving electricity in Brazil is even greater than the fatal cases caused by dengue.

According to data from [3], between 2013 and 2015, an average of 830 cases per year of accidents involving tasks with electricity and about 36% of these occurrences resulted in death. In 2016, occurred an average of 749 accidents with electricity, and 250 of these accidents resulted in death. [10] mentions that 70% of the patients who were victims of electric shock who were treated at a

Burning Treatment Center in the State of Ceará were caused by work accidents.

Based on this information, it is important to apply the applicable regulatory standards, as protective measures always seeking to ensure the safety and health of the worker. Thus, this paper aims to describe the application of Regulatory Standard number 10 (NR-10) in two companies of Manaus, Amazonas, being them medium-size and large-size, in order to classify them as to compliance with the application of NR-10 identifying possible changes to the facilities required to prevent accidents.

II. THEORETICAL REFERENCE

Works with electricity started in Brazil in the nineteenth century, which was produced by generating plants formed by farmers, businessmen and local traders. Only with the arrival of the Canadian company Light in 1899, which started with incentives for structural actions such as the construction of large electric utilities so that they could meet the growing demand for this service [12].

The 80 decade were marked mainly by the beginning of operation of the Itaipu Hydroelectric Power Plant, and its activities started in 1984, a binational plant in Brazil and Paraguay [10]. For [8], electricity is the main driver of society, governing the functioning of important parts, such as the social and economic development of countries, where the advancement of technology and the structuring of information technology should directly

contribute to the elevation of quality of life of the population.

Considering only households in urban areas, only 0.9% of the Brazilian population has no access to electricity services and only 2.2% considering the entire Brazilian population in urban and rural areas. According to [7], through the demographic research, the value quoted describes that the population is almost entirely affected by electricity [11].

Through a study conducted in the USA, from 1982 to 1994, by the National Institute for Occupational Safety and Health (NIOSH), it was found that the most common accidents occur in five different contexts [15]:

- a) Direct contact with energized line;
- b) Direct contact with energized equipment;
- c) Contact of vehicles with energized line;
- d) Equipment incorrectly installed or damaged;
- e) Contact with energized conductive equipment.

Between 2013 and 2015, an average of 764 cases were registered per year and about 75% of these occurrences died. According to [2], in 2016, using data from Agência Nacional de Energia Elétrica (ANEEL), for occurrences involving only the electrical network, 209 deaths involving only the electrical network were registered and 605 deaths occurred involving both the electrical network and other accidents with electricity.

The losses caused by accidents at work, being physical, material, psychological or any other nature, are unimaginable. For accidents with registered workers who are notified and identified in official statistics, the costs generated in Brazil are around R\$ 70 billion, and the country spends on average R\$ 100 billion per year, with compensation and treatments to occupational accidents. With this, behind only China, the United States and Russia, Brazil occupies the 4th position in the ranking of the worst country in the world in work safety [10].

For [2], professionals who are exposed to electricity in everyday life, the risk of suffering an accident such as shock and electric arc, increases significantly, and the worker can suffer from serious injuries, or even die. [10] defines electric shock as the disturbance of nature and various effects that manifests itself in the human organism when it is crossed by an electric current. [5] mentions that the two factors that determine the severity of the injury caused by shocks are:

- a) The intensity of the circulating electric current (amount of electric current that will circulate through the body);
- b) The path of the electric current (depending on the path taken by it, being greater severity those in

which electric current passes through the heart) (Table 1).

Table.1: Electric current effects

Electric current intensity (Amps)	Consequences on the human body
1-10mA	Creeps sensation.
10-20mA	Painful feeling.
10mA<or<20mA	Breathing difficulties, may die or suffocate.
100mA	Cardiac fibrillation
200mA	Severe burns and cardiac arrest
1A	Severe burns, necrosis and instant death

For [5], the factors that most cause accidents are seen as: a personal factor of insecurity, this factor takes into consideration human behavior such as: excessive worker self-confidence, carelessness, the rush to finish the service, among others, and also the unsafe condition of the environment: services done under hazardous conditions.

For [2] occupational safety is a grouping of measures applied in the prevention of occupational accidents and diseases, aiming to protect the health and integrity of the worker. The author also reports the creation of official document number 3.214 that sanctions regulatory standards, and have the necessary requirements related to occupational safety and medicine, as in the case of NR-10 that directs such objectives to workers who interact directly or indirectly in facilities.

[13] cites several benefits regarding the application of NR-10 in table and flowchart format. An example of the benefits cited by the author concerns the industry point of view as shown in Fig.1.

Through Social Security data, [17] mentions that between 2000 and 2017, 4,466 accidents with electricity were recorded in Brazil and that with the update of NR-10 by Ordinance MTE No. 598, of December 7 As of 2004, it was expected that the occurrence of these accidents would decrease as a result of the companies' obligation to implement control measures and preventive systems, in order to guarantee the safety and health of workers who, directly or indirectly, interact in electrical installations and services with electricity, a fact that did not happen as shown in Fig.2.

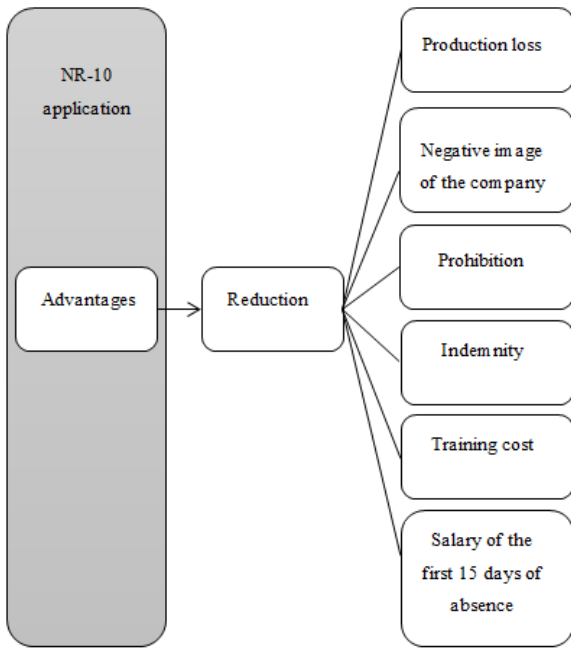


Fig.1: Benefits of NR-10 from an Industry Perspective



Fig.2: Evolution of the frequency of work accidents with electricity according to the year of occurrence. Brazil, 2000-2017.

III. MATERIAL AND METHODS

Data collection was performed through on-site visits to one of the two companies studied in this research, and was accompanied by a professional responsible for the visit. The data of the second company were obtained through official documents made available by it.

In addition to NR-10 as an analysis tool in companies, bibliographic and electronic materials on work safety and electricity were also used to better understand the preventive measures and the risks to which workers are exposed to each type of service. The companies that participated in this research have a security policy that prohibits the reproduction of photographs in their internal environment, so that no confidential information leaks or

industrial secrets do not occur, so we did not use images of the companies in this article.

As for the evaluation method, the two companies studied were divided into two categories:

- a) Large-sized Company (LS);
- b) Medium-sized Company (MS).

In addition to the annual business turnover and the activities performed by a company, the main aspect of differentiation between the types of companies is their number of employees. For industry, medium-sized companies have between 100 and 499 employees and large companies over 500 employees [14].

Although some companies have their productive sector divided into some subsectors, this research aimed to analyze all of them in general as a single sector, considering that this is the space where there is the largest transition of people in most companies, and where there is a greater need for risk prevention measures.

The aspects analyzed by this research in each company were:

- 1-The Low Voltage Distribution Board (LVDB);
- 2- Substation, signaling and single-line schemes;
- 3-The qualification of employees and punishments applied to employees who perform any activity with electricity in non-compliance with [4].

Finally, when the evaluation process regarding the application of NR-10 was concluded, these companies were classified according to conformity, indicating whether they need adjustments in their preventive methods.

IV. RESULTS AND DISCUSSIONS

4.1 Large-sized company (LS)

The law requires companies to maintain up-to-date single-line wiring diagrams of their establishment with the grounding system and other equipment specifications, as well as protective devices. Establishments with an installed load greater than 75000 watts shall constitute and keep current, in addition to the single-line diagrams, the electrical installation chart consisting of: single-line diagram, descriptive memorials, maintenance reports or operation manuals that must be accessible to workers, kept organized and updated for consultation and inspection [16].

Through official documents obtained by this company, it was found that the application of NR-10 is always essential, because it goes through constant external audits because it is a worldwide known company. Therefore, LS meets all points proposed by NR-10, such as the provision of collective and individual protection equipment, updated availability of the chart of

electrical installations and single-line schematics, additional risk analysis and control and the selection appropriate of safety signs.

4.1.1 Substation, signaling and single-line scheme

According to the analysis of the application of NR-10 in LS in the substation, the announcement signs and single line scheme are in compliance, it was found that the company also meets all the requirements described in the topic above.

4.1.2 Training and appropriate punishments

According to [1] the design, execution, verification and maintenance of electrical installations should be made only for qualified persons.

LS offers free and frequent internal training programs to its employees, such as: safety in electrical installations and services (NR-10); safety at work in machinery and equipment (NR-12); unhealthy activities and operations (NR-15); dangerous activities and operations (NR-16); explosives (NR-19); Safety and health at work in confined spaces (NR-33); work at height (NR-35); fire brigade, and others (each employee is required to have at least ten training courses per year).

As for the punishments, LS has a monitoring system with over six hundred surveillance cameras scattered throughout the production complex, internal and external, which record 24 hours a day, 7 days a week, so any accident is recorded. If it is not possible to determine the causative agent of the accident, an internal investigation is made with people who were close to the scene of the accident and also with the boss of the injured person to find out the reasons and causes as well as a technical analysis of the equipment where the accident occurred.

At the end of these investigations was possible to define whether or not human error has occurred, whether or not the injured person was using the appropriate Personal Protective Equipment (PPE) for the activity, so that, depending on the degree of the offense, appropriate punishments are applied between verbal warning, written warning, temporary suspension of activities and company termination (just cause).

4.2 Medium-sized company (MS)

The on-site visit to this company was so important, as it was observed, the non-correct application of the NR-10, because there are not any electrical document about the LVDB of this company, though the physical structure it was in accordance with the current standard, it had the acrylic protective cover, the components such as busbars and circuit breakers, were correctly fixed, clean and without heating signal.

The cables and wiring were unorganized and was not properly identified, there was no way to detect the circuit

breakers of each circuit, it was only possible to be identified by people who worked for a long time in contact with the this electrical cabinet.

4.2.1 Substation, signaling and single-line scheme

During the period of the visit to the MS, the company's substation was in the process of refurbishing and maintaining the generator motors to bring about improvements to it, however, what was observed was the non-availability of PPE's for people who may have access to the site, poor signage with fallen signs and printed on ordinary paper on which the rain had already degraded.

The substation is located next to part of the production process, that is, there is a large movement of people around it, and due to no proper signage or supervision these employees circulated freely near the substation, where could not be accessed by unauthorized and untrained persons but it is incorrect to say whether this part of the company is compliant or not, given that many changes occur in the period of maintenance and renovation in an environment in general.

4.2.2 Training and appropriate punishments

According to information obtained from the local Serviço Especializado em Engenharia de Segurança e em Medicina do Trabalho (SESMT), the company annually offers the courses of NR-10, NR-33, NR-35 and SEP (Electric Power System), however according to some employees who was explaining some procedures performed within the company, the company does not oblige to take the training course, they hires employees who are already qualified that can perform any activity that is necessary in the company.

According to [6], it is understood by personal insecure factor: when the activities are performed by people with lack of practice, training, ill will or bad physical condition. In addition the author still defines unsafe act, when the worker does not take proper care or make a task, or still does not respect the safety standards.

When the employee is not properly trained, automatically, when performing tasks outside his or her purview, the employee is performing acts without the security necessary to perform that task. For proper employee punishment, companies must empower their employees to be aware of the risks to which they are exposed.

When the employee is not properly trained, automatically, when performing tasks outside his or her skills, the employee is performing acts without the necessary security. For proper employee punishment, companies must empower their employees to be aware of the risks which they are exposed.

Some companies are supervised by the ANEEL as generation, transmission, and distribution companies of electricity and it is responsible for supervising them in order to ensure the provision of quality services. [9] state that when these companies do not comply with the rules and laws of the electricity sector, they are subject to punishments ranging from warning and fines until up termination of the concession, in this context, the control of these companies and even of the service providers became more rigorous.

V. CONCLUSION

Based on the study, during the on-site visit and through official documents made available by the company, in general, several non-conformities were observed in one of the companies studied in which some NR-10 items are available or not available preventive measures through risk analysis, lack of supervision by the employer for irregular practice in activities that are outside the employee's training, poor signaling or even lack thereof, among other requirements imposed by this standard.

One of the first thoughts that was taken into account regarding the non-compliance of this company was the fact that it is not a worldwide recognized company and does not have rigorous supervision by public or private agencies regarding the application of the rules governing the safety of your employees.

As for the problems encountered on the premises, the following solutions are suggested, the implementation of a periodic program of evaluation, preventive maintenance and corrective maintenance, the application of the necessary signs in places that require this procedure, installation of substation identification, protection of switchboards and identifying circuits, creation of a single-line diagram, strict supervision on the use of PPE in the activities practiced in the companies and the rigorous supervision on the access of people to substations.

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