# An analysis of the compliance aspects of NR 10: a case study in a substation of the Manaus Metropolitan Region - AM

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## Abstract

*The Regulated Standard (NR-10) is a standard that establishes minimum requirements and conditions with the stated objective of guiding the adoption of preventive systems control measures. The objective of this study is to analyze the compliance of NR 10 in a substation, analyzing as inherent activities to the enterprise according to the standards of standardization. A research was conducted based on a descriptive and observational study, and was implemented through an on-site study based on data collection and information gathering in a substation located in the southern region of Manaus - AM. It is responsible for the distribution of energy throughout the south and center-south of the city, feeding about 450,000 people with the availability of 188,890 kW of power. It was concluded that it is essential that the electricity supply companies are fully in compliance with the requirements and surveillance standards in the country, given that the conservation of workers who deal with direct work in high and low pressure spaces be observed with a much more accurate strategic look.*

**Keywords:** NR-10; Maintenance; Substation;

## 1. Introduction

Large cities, especially metropolitan regions, need large energy production to be able to feed local production and move energy consumption to supply society. Substation studies show how these large companies develop methods and actions that serve society from the power supply.

In addition to the energy supply aspect, there has been a concern, in recent years, over the adequacy of standards and standardization panoramas for space adequacy, in order to increase occupational safety and make risk mitigation more effective. and improving the most appropriate space-assurance techniques for doing work.

Energy supply can be considered as one of the main services offered to society, either through public concession or by state modality, so that its distribution is fundamental for social development. To this end, there is a need to develop mechanisms that ensure the full maintenance and adequacy of distribution spaces so that the preservation of the environment, the safety of life and the full functioning of distributors do not adversely affect society.

In addition, it is understood the importance of standardizing procedures and adjusting power distribution spaces to ensure integrity and safety in the power supply process. Therefore, the objective of this study is to analyze the compliance of NR-10 [1] in a substation, analyzing the activities inherent to this undertaking according to the standardization norms.

Maintenance has its appearance in the period of antiquity with the emergence of the first major constructions demands for economic growth and to meet the demands of society. In the period of the Industrial Revolution, the rise of new tools with the expansion of industrial machinery brought to light the academic debate on the need to improve tools and control mechanisms to maintain machine operation and optimize production [2].

NBR 5462 [3] conceptualizes maintenance as a set of activities that aims to apply procedures that guarantee the full functionality of a product in order to optimize its resources. For this, it is understood that maintenance is not an isolated step, that is, it consists of a systemic procedure integrated with other functionalities.

According to [4], maintainability refers to the conservation method or result for performing ordinary functions, such that there is full conservation so that its usability can be extended despite the frequency of use. This concept derives from the relevance of maintenance in the production process, so it is understood that it is necessary in the strategic and operational planning of any organization.

[2] discusses that the mission of maintenance goes beyond the operational phase, being also present in the tactical and strategic planning process of the organization. Maintenance actions can be planned periodically, aiming to actively participate in the production cycle in the organization.

[5] analyze that maintenance can enter the organization planning in a broad and objective way, according to the proposed actions and their determined role in each phase of production. The objectives of maintenance in an organization can be developed in several lines and fronts, being necessary to be predetermined and subordinated.

[6] mention that maintenance objectives need to be aligned with an integrated set of actions that determine their role in each phase of production. The life cycle of an accurate equipment is accompanied by a series of maintenance actions from a present and active monitoring program in order to offer quality parts and thus ensure their best performance.

This standard applies to the generation, transmission, distribution and consumption phases as well as included in the construction, assembly, operation and maintenance projects of electrical installations and any work carried out in close proximity to areas with electricity, in accordance with current technical

standards. [7]. [1] is a standard based primarily on guidelines that address operator safety when contacting objects or environments where electrification is present.

Note that [1] is a standard that establishes minimum requirements and conditions with the primary objective of guiding the adoption of control measures for preventive systems. In addition, its scope of action is direct prevention in guaranteeing the safety and health of workers, as well as directly guiding the methods and the way of working in electrical installations [8].

The NR-10 can be applied to the main stages of the control process in electrical installations: generation, transmission, supply, distribution and consumption. In addition, it can also act in the design and implementation phases of the distribution companies, such as: construction, assembly, operation, maintenance of building installations in its electrical composition aspects and any other work developed around an electrical distribution area [1 ] [9].

It is observed that the NR-10 acts as a regulatory instrument with application in the most diverse areas and stages of execution in the development of activities within the power distribution [1]. [10] argues that NR-10 is involved in the implementation of control measures to avoid risks and ensure the safety and health of work exposed to risk, ie, it instructs companies to perform tasks that enable the safety condition. in the provision of work.

## 2. Methodology

The substation is located in the southern region of the city of Manaus - AM, being responsible for the distribution of energy throughout the south and center-south of the city, feeding more than 450 thousand people with the availability of 188,890 kW of power.

The inspection period was July 10-20, where from a preliminary study, according to data provided on the company's website, it is able to meet demand growth of up to 35% by 2023, to supply local and other parts of the city. The distribution covers about 16 neighborhoods and the current space covers a total area of 88,000 m² - including all workstations and access areas, as well as administrative and operational management buildings.

The research was conducted based on a descriptive and observational study [11], being implemented through an on-site study, based on information gathering for direct application in the substation workspace, with measurements, capture and information records. and images for data processing.

The research schedule was defined according to the technical visits made on site, together with the presence of responsible team that guided the entire process. The study was divided into three stages:

(i) Area inspections; (ii) initial diagnosis and preliminary report of spaces; (iii) preparation of the proposal to adapt to NR 10 [1].

From this adequacy, it is suggested an adequacy report based on NR-10, which was presented: Guidelines for improvement actions (preventive); prevention actions based on work risk analysis; work operationalization measures in the substation; recommendations.

## 3. Results and Discussion

The presentation of the study was through an analysis that took place through technical visits to the energy

distributor. Follow-up was performed by a technical team and the collected data were made available in tables for better identification. Subsequently, the estimated measurements and observations regarding NR-10 adequacy [1] were recorded.

For an inspection analysis it is necessary to know where to apply, the possible potential risks and adequacy measures. Thus, Table 1 presents the schedule of the inspections carried out in the initial and preliminary phase of the study from the technical visits in the energy distribution sectors.

Table1. Ckeck list presenting exercises for different activities linked to NR-10.

| Place | Potential Risks | Estimated Measures | Comments |
|---|---|---|---|
| **Electrical Components Sector** | Risk of accident | Sector Signage | Low brightness of workspace |
| **Maintenance Sector** | Ergonomic risk | Inadequate workstation structure | Lack of work real estate suitability |
| **Production and Operations Control industry** | Accident Risk and Ergonomic Risk | Low light; No signaling | Adequate space to make shift work easier, especially night shift. |
| **Administrative sector** | Risk of accident | Lack of planned real estate for the sector | Perform maintenance on power distribution boards |
| **South and North Alaskan Logistics Sector** | Risk of accident | Electrical Wiring Display in Control Wing | Suit the spaces |
| **Machine Operation Wing** | Risk of accident | Visual signage | Perform signaling by machinery. |
| **Machine Operation Wing - Part 2** | Risk of accident | Operators Signaling | Perform signaling by machinery. |
| **Periodic visits in the distribution yard** | Accident Risk and Physical Risk | Operators Signaling | Perform the signaling of spaces. Identify the distribution grids of distribution networks. |

Source: Own authorship (2019).

The stage of the technical visits was the initial and preliminary diagnosis of the study to collect data and observations about the site. The inspections were performed by department and according to permission instructions from the Maintenance Coordination (CM).

The identification of the risks was categorized according to [1] and the observations of [12] as “accident risk”, “ergonomic risk” and “physical risk” - these three categories are fundamental for observation in an adequacy survey in a risky workspace.

For the initial diagnosis phase, it started by capturing information collected during the technical visits and, subsequently, by identifying the items of the [1] that fit according to the situation observed in the survey

process. Table 2 presents the initial checklist stage, which corresponds to the general survey of electrical installations according to their suitability and safety aspects.

Table 2 - Checklist for verification of the necessary items in the electrical installations.

| Item # | Item from | Item Description |
|---|---|---|
| **1.1** | NR-10 | Correct identification of access wings. |
| **1.2** | 10.3.9d | The standardization of outgoing accesses that are within the specified standards according to NBR 140390. |
| **2.1** | 10.10.1, NR-26, NBR 14039 | Visibility of appropriate access doors with signage. |
| **2.2** | 10.9.4 | Doors with emergency exit. |
| **2.3** | 10.12 | The power distribution boards are fixed at points with isolation. |
| **2.4** | NR-23 | Signaling in hazardous areas. |

Source: Adapted from EletroPaulo (2009)

The checklist was also based on NBR 14039 - Medium voltage electrical installations and NBR 5410 - Low voltage electrical installations. In this topic there was comparability of the data collected during the technical visits with the adequacy study conducted by the EletroPaulo team (2009). This comparison allowed, as noted [16], a holistic analysis of employee circulation spaces, so that space adjustments in line with regulatory standards are crucial to avoid any type of accident.

After performing the technical visits in the preliminary stage together with the data collected in the initial diagnosis, the preparation of the NR-10 adequacy proposal was initiated after the checklist as a guiding point [1]. Furthermore, according to [12], the NR-10 compliance phase is a crucial step in any company's work safety planning, and it is the sole responsibility of the company to provide the necessary adjustments to ensure the employee's quality of work. .

### *3.1 - The first phase of the analysis was carried out in Central Area 1*

Which is located in the northern range of the distributor. This area comprises 42% of the local supply and distribution of energy to the neighborhoods that the distributor feeds.

Table 3 shows the phase of proposition of adequacy for the Central Area 1 (Power Sector) of the energy distributor. This area consists of one of the main areas of energy supply and distribution.

Table 3 - Suitability Proposals - Central Wing 1 (Covering and Protection Network).

| | **Procedure** | **Potential Risks** | **Control measures** | **Comments** |
|---|---|---|---|---|
| | **CENTRAL AREA 1 - FOOD SECTOR** | | | |
| **VISUAL INSPECTION** | Energy distribution (Inspection of conservation status) | Risk of accident (tensions) | Prune outdoor areas (trees) | Outside area with tall trees, without pruning, and with very low wall. |

| | | | | |
|---|---|---|---|---|
| **PREVENTIVE ACTION** | Adjust the mains according to the maintenance time of the power cables (check the maintenance schedule) | Risk of accident (tensions) | Update the power cable cabling maintenance schedule | Increase the power grid by 1.5 m at the front side next to the generator. |

Source: Own authorship (2019).

Adjustments according to [1] in the schedule of building maintenance and spatial adjustments are fundamental to ensure the maintenance of equipment equipment, especially those that make up the power grid. [14] notes that the adequacy of physical structures is important to avoid accidents, such as areas exposed to natural elements such as lightning, trees, animals, etc.

Table 4 shows that the risks in the high and low voltage areas were detected based on the space analysis, which identified the presence of large trees that could cause an accident if there is no control on pruning. [18] analyzes that every high voltage (AT) physical structure needs to be regulated by specific technical standards, such as NR 10, so that the entire structure that makes up the distribution system is preserved and functioning properly and effective.

Table 4 presents the analysis performed in the Central Wing 1 (Maintenance Sector). The sector is responsible for the entire system of maintenance of the small, medium and large equipment of the power distribution company.

Table 4 - Suitability Proposals - Central Wing 1 (Maintenance Sector).

| | **Procedure** | **Potential Risks** | **Control measures** | **Comments** |
|---|---|---|---|---|
| | **ALA: CENTRAL AREA 1**<br>**LOCATION: MAINTENANCE SECTOR** | | | |
| **VISUAL INSPECTION** | Conducting power cable changes for motors and power generators. | Physical risk<br><br>Risk of electric shock | Space signage<br><br>Safety Plate Replacement (Upgrade to NR-10) | Include this information in the annual schedule. |
| **PREVENTIVE ACTION** | Realization of exchanges of parts of the power supply circuit of the generators. | Physical risk<br><br>Risk of electric shock | Use of PPE<br><br>Equipment Acquisition | Purchase of safety equipment for all employees, including those on duty. |

Source: Own authorship (2019).

According to [14] the electrical installations need an adaptation and a maintenance program in continuous regime, that is, so that the parts with higher wear rate are replaced in a timely manner. [1] in its topic

10.2.9.1 guides the need to use individual equipment in any environment where the worker is exposed to imminent risk.

Electric shock, according to [14] is the reaction in the body caused by nerve stimuli generated from an electric discharge, ie, contact with a passage of electric current from an external source. In the case of electricity distributors, the accident rate is very high and the demands of the occupational safety team need focused attention to reduce the risks of electric shock and, consequently, the risks of physical damage, which may eventually lead to accidents. death.

Table 5 presents the analysis performed in the Operations Control Sector. The sector is responsible for the coordinated maintenance of operations in general: logistics, material transportation and storage of inputs.

Table 5 - Adequacy Proposals - Central Wing 1 (Operations Control Sector).

| | Procedure | Potential Risks | Control measures | Comments |
|---|---|---|---|---|
| | **ALA: CENTRAL AREA 1**<br>**SETTING: OPERATION CONTROL** | | | |
| **VISUAL INSPECTION** | Work Area Inspection (internal and external) | Risk of accident<br><br>Physical risk | Isolation of risk areas through sector reallocation | The sector is close to an area of difficult access. Changing to another nearby room at the side entrance is recommended. |
| **PREVENTIVE ACTION** | Readjustment of operating and inspection spaces | Risk of accident<br><br>Physical risk | Reactivation of the external and internal illumination of the central passage | - |

Source: Own authorship (2019).

For [16], the adequacy of the physical space in the control, operation and inspection areas is essential to avoid any problems related to physical accidents in electricity areas. The NR-10 in its topic 10.4.3 for the preservation of space with electrical equipment and spatial adjustments of buildings to preserve the protective features of the site [1].

### *3.2 The second phase of the analysis was performed in the Central Area 2*

Which is located in the southern range of the distributor. This area comprises 58% of the energy supply and its main characteristic is the size of the physical space (about 800m²) and where the low and high voltage areas are located, concentrating the power phase with the highest energy supply capacity.

Table 6 presents the Low and High Voltage Area (Control and Maintenance). This area concentrates most of the power generators, as well as the electrical structure that feeds the distribution process. The space verification and the adequacy proposition according to [1] were performed.

Table 6 - Suitability Proposals - Central Wing 2 (Low and High Voltage Area).

| | Procedure | Potential Risks | Control measures | Comments |
|---|---|---|---|---|
| | **ALA: CENTRAL AREA 2**<br>**LOCATION: LOW AREA AND HIGH VOLTAGE** | | | |
| **VISUAL INSPECTION** | Protection of supply areas (Generators) | Physical risk<br>Risk of electric shock<br>Risk of death | Protection with 3.3mm screen reinforcement on the side of the generators. | Include proposal in the company's physical fitness schedule. |
| **PREVENTIVE ACTION** | Change of protection standards (Generators) | Physical risk<br>Risk of electric shock<br>Risk of death | Carry out the placement of the guards and signal with new plates according to NBR 13434. | - |

Source: Own authorship (2019).

The suitability of low and high voltage wool is paramount for ensuring the safety and health of the worker in the operation of any service performed in this area, where [17] describes the conduct of a study in which the assessment performed in high voltage sectors. The risk of accidents is measured by up to 32% in energy distributors in Brazil, ie, a risk that needs to be avoided through precaution, based on the guidelines presented by the adequacy and regulation standards.

Table 7 presents the Coordination of Energy Distribution and Measurement Control. The sector is responsible for the coordination of the high and low voltage areas and for the management of the distributor (Central Wing 1 and Central Wing 2) with the function of controlling measures, variability and changes in distribution.

Table 7 - Adequacy Proposals - Central Wing 2 (Coordination of Energy Distribution and Measurement Control).

| | Procedure | Potential Risks | Control measures | Comments |
|---|---|---|---|---|
| | **ALA: CENTRAL AREA 2**<br>**SETTING: ENERGY DISTRIBUTION AND MEASURE CONTROL COORDINATION** | | | |
| **VISUAL INSPECTION** | Observation of physical area coverage. | Physical risk<br>Risk of electric shock | Supported tent construction to isolate administrative sectors<br>Relocation of the administrative area of the generator contact area | Control rooms are just 2 meters from one of the power generators |

| | | | | |
|---|---|---|---|---|
| **PREVENTIVE ACTION** | Build temporary zinc or other mental tents in steel frame mode the physical safety of space. | Physical risk<br><br>Risk of electric shock | Verification of close space for relocation of administrative areas. | Present this measure in the planning of the company's Occupational Safety Coordination. |

Source: Own authorship (2019).

It is noted that the Coordination of Power Distribution and Measurement Control has a location that did not follow the expansion of power generators in the distributor. Although the physical space is high, the control rooms and administrative rooms are very close to the generators and the high and low voltage areas, offering an imminent risk.

[14] analyzes that the protective measures recommended by NR-10 in item 10.7 recommend for worker involvement in high voltage areas, especially regarding the proximity of space in the execution of their activities. Therefore, it is understood that the energized facilities must be built in a way that does not compromise the physical integrity of the worker, therefore, the companies need to observe the composition of the physical space.

### *3.3 As recommendations*

The stage after the initial diagnosis (checklist) and preparation of the NR-10 adaptation proposal is the presentation of the study recommendations. The study, based on [1], made some general recommendations regarding the adequacy of physical space, adequacy in the service improvement structure and the presentation of solutions and implementation measures in the medium and long term.

Implementation of the Annual Predictive Maintenance Program (PMPA): It was observed the company's immense difficulty in keeping up with the maintenance deadlines of the generators and equipment of the Central Areas 1 and 2, mainly due to the large physical space and little specialized labor. Therefore, the creation of the PMPA was recommended as a strategic tool for the implementation of a specific policy directed to the maintenance of the generators of the supply units (UF) under the direction of the Maintenance Sector. Currently the company does not have a specific maintenance policy for predictive maintenance, only for corrective maintenance.

Improvement in the signaling of internal and external areas: perhaps one of the administrative decisions that, at first, may show a certain inaccuracy or a sense of needlessness. However, it was observed that the substation has a huge gap in the signaling aspects (administrative areas and risk areas) - which leads to an imminent risk to the health and quality of life of the worker. For this, it is recommended to change all nameplates from [1] in order to standardize access spaces and avoid future problems.

Systematization of maintenance actions with the work safety coordination It was observed that there is a distance from the work safety coordination planning actions, with the substation maintenance sectors. In order to have a coherent maintenance planning, it is necessary to align actions so that the two wings participate. It is recommended that a standard operating procedure (SOP) be created to standardize maintenance actions along with the needs of sector adequacy to preserve worker health. This document will serve as a guiding principle for participatory and continuous joint decision making.

## 4. Conclusion

It is essential that the electric power companies are fully in compliance with the principles and regulations in force in the country, given that the preservation of workers who deal with direct work in high and low voltage spaces must be observed with much more accurate strategic look.

In order to avoid problems such as accidents in contact and exposure to electrified systems and reduce the possibility of unforeseen events, such as environmental factors, it is necessary to create adaptation policies that primarily address the conservation of worker health.

The NR-10 is a norm that promotes and structures the actions and guidelines that help in this process of adequacy, being primordial to adjust the routine work procedures according to actions that value, first of all, the worker's life.

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