



LIVE WORK ON THE LIVE LINE: HOW ACTIVITY ERGONOMICS CONTRIBUTES TO THE ANALYSIS OF WORK IN RISK SITUATIONS

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Summary

The electrical sector poses risks to workers, and as a result of this and the other complexities involved in this type of work, deaths and accidents involving electricians are significant. This article presents data from a thesis conducted with Live Line Electricians (LLE) and discusses how Activity Ergonomics (AE) contributed to the analysis of work in hazardous situations, particularly the work of these operators. This study was conducted at a power distribution center of a private company in the interior of São Paulo state with LLE workers who were part of the company's workforce. This action research applied stages of Ergonomic Work Analysis (EWA), focusing on the tasks performed by these workers on electrical poles and pruning vegetation. The study highlighted the individual and collective strategies and operating methods present in the work of LLE workers, ensuring not only the quality performance of hazardous activities but also the preservation of health and life. This research also highlighted the importance of EA for analyzing work in hazardous situations, especially ELV work. Live work on live lines could only be viewed broadly and comprehensively through the ability to explain the work reality, which is so important for EA.

Keywords: Activity ergonomics, Live Line Electricians, Practical intelligence; Electrical Sector, Accident Prevention.

1. INTRODUCTION

In the context of the energy sector, the law considers dangerous activities or operations to be all those that, due to their nature or working methods, place the worker in permanent contact with electricity (Brazil, 2019).

Electricians' work involves a variety of risks. Scopinho (2022) describes physical, mechanical, chemical, and biological risks, as the work is performed at heights and under high temperatures, prone to animal attacks, contamination, and high physical and cognitive effort (Scopinho, 2002). Psychosocial risks associated with work are also present, primarily

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associated with fears and anxieties due to the high degree of danger involved in electrical grid activities (Salvagni & Veronese, 2017).

As a result of this and the other complexities involved in this type of work, deaths and accidents in the sector are significant. According to the Statistical Yearbook of Abracopel (Brazilian Association for Awareness of the Dangers of Electricity), there was an increase in the number of accidents caused by electrical sources during the first half of 2023. The document shows that the total number increased, both in terms of accidents and deaths. In 2022, 949 total accidents (shocks, fires, and lightning) were recorded; in 2023, the number rose to 992. Deaths also increased, from 384 in 2022 to 399 in 2023 (De Souza, Martinho & Martins, 2023).

The work of electricians in electrical power systems (EPS) involves energy generation, transmission, and distribution companies, building, installing, and maintaining proper operating conditions for the electricity sector. In power distribution, there are two main categories of electricians: those who work on live lines and those who work on dead lines. Live line electricians (LLE), the focus of this study, work using the contact method on energized networks, which poses even greater risks.

Various approaches to the field of work, with distinct theoretical and methodological perspectives, propose to study hazardous activities and accidents. This article aims to present data from a thesis conducted with Live Line Electricians (LLE) and discuss how Activity Ergonomics (EA) contributed to the analysis of work in hazardous situations, particularly the work of these operators.

2. ACTIVITY ERGONOMICS, RISKY WORK AND ACCIDENTS

In Brazil and around the world, there are diverse perspectives for understanding and analyzing workplace accidents. A simplistic, but still prevalent, view is that unsafe acts in the workplace are primarily the result of individual behavior. Error detection theories, for example, suggest that accidents are intentionally caused due to noncompliance with established safety standards and procedures (Vilela, Iguti, & Almeida, 2004).

Authors such as Allwood (1984) and Norman (1981), drawing on the Anglo-Saxon tradition, develop methodologies for analyzing workplace accidents with a positivist approach, focusing on the human error paradigm. In the Brazilian context, this perspective is supported by NBR 14280/2001, which classifies accidents and analyzes them based on factors related to personal insecurity, unsafe acts, and unsafe conditions.



These analyses seek to eliminate risks by attributing responsibility for accidents to human factors, personal attributes, and mental processes that can lead to recklessness. The person-centered error management approach focuses on reducing the variability of undesirable behaviors, using training methods and corrective measures that may include restrictions on autonomy, threats, and punishments (Reason, 2000), which are not beneficial from the perspective of understanding and addressing the causes of accidents.

In order to corroborate the above, Vilela, Almeida and Faria (2021, p. 285) add that such practices seek "maximum technical and economic efficiency to the detriment of noticeable normative disorder and precariousness in decision-making processes, without taking into account the entire project conception and ignoring the ethical and economic aspects and project deficiencies." Beyond a simplistic analysis, the authors point out that they propose short-lived solutions in terms of accident prevention.

On the other hand, approaches that involve the analysis of multiple variables in the occurrence of workplace accidents propose a connection between organizational aspects and the determinants of workplace accidents, addressing them systematically, considering their social dimensions. Risks are understood as broad, situational phenomena, not associated solely with the conscious actions of workers, but with a chain of complex relationships that include organizational aspects, individuals, and their collective (Doppler, 2007).

Based on these assumptions, the systemic approach follows a path of analysis and intervention regarding accidents and health problems in the workplace, going beyond the identification of visible problems. By investigating root causes and proposing comprehensive solutions, this approach seeks to transform work processes and prevent the occurrence of new incidents (Vilela, Almeida, Faria, 2021).

Activity Ergonomics (Guérin et al., 2001) as a theoretical and methodological assumption fulfills this purpose in risk analysis, as it emerges as an approach that is interested in "what" workers do and "why" they do it, considering the human and technical variabilities of work, as well as the singularity of work situations, in what is called 'situated action' (Antipoff, 2023).

For Ergonomics, activity, also called real work, is understood as a mediator of the man-work relationship, as it expresses the way in which each individual mobilizes their capacities (physical, cognitive and affective) to achieve production objectives or the prescribed work, according to the variability present in work situations (Guérin et al., 2001).



In the case of risks, it is understood that following work rules and regulations is not enough to prevent accidents, as the prescriptions only consider the task—that is, the predictable and objective aspects of the work. Therefore, Activity Ergonomics foresees not only the analysis of the task, but also of the activity in the work situation (Gemma & Abrahão, 2023).

This involves considering the complexity of reality and the invisible aspects of work, including planning, assessments, decisions, adjustments, and real-world impediments. These can lead to an inability to control all the variables involved in the task, culminating in accidents or incidents (Diniz, Silva, Campos, 2021). Within this perspective, there is a need to understand work from the perspective of its participants, as proposed by Ergonomic Work Analysis (EWA) and other participatory methods for creating more effective management strategies for occupational safety (Rocha, Daniellou, Mollo, 2014).

3. METHODOLOGY

This article is based on the results presented in Traldi's thesis (2022), which aims to analyze the ELV work of a private electricity company that has been operating in the Brazilian market for over 100 years.

Specifically, the study focused on a power distribution center owned by this company, located in a municipality in the interior of São Paulo state. The research took place between 2018 and 2021 as part of a Research and Development (R&D) project funded by the Brazilian Electric Energy Agency (ANEEL).

Eight electricians, aged approximately 35 to 55, participated in the study. All of the electricians were male, part of the company's own workforce, and had at least five years of experience with the company.

The method used in the Thesis is based on Action Research through the application of stages of Ergonomic Work Analysis (EWA) (Abrahão et al., 2009; Guérin et al., 2001), such as: demand analysis, data collection on the company's operation through the collection of information about the organization and the population researched, choice of work situations to be analyzed and global observations of the activity.

To this end, documentary analysis, individual and collective interviews with managers and electricians and visits to the energy distribution center and the addresses where work was carried out at the time of carrying out tasks on electric poles and pruning vegetation were carried out to analyze the work situations.



Consecutive verbalizations and confrontations were considered after the completion of each activity, since for safety reasons, simultaneous interaction with the operators during the activity was not possible. The actions were recorded through field diaries, images (photos and videos), and audio recordings. It should be noted that the study was approved by the Research Ethics Committee (CAAE: 16531119.0.0000.5404).

4. PRESCRIBED ELV WORK

ELV work is preceded by specific Regulatory Standards (NR), including NR 10, which addresses Safety in Electrical Installations and Services. These standards detail the need for qualifications to perform work on de-energized and energized low- and high-voltage electrical networks, the right to refuse work in situations that present serious and imminent risks to the safety and health of workers or others, collective and individual protective measures such as the use of protective equipment, the need for prior assessment of the work situation, and the need for work not to be performed alone, especially when dealing with high voltage, among others (Gemma et al., 2022).

In addition to the standards more broadly established by law, Traldi's (2022) research found that the company under study applies such regulations through the Company's Standardized Task Manual for Maintenance of Energized Distribution Networks and Lines - Class 15kV to 35kV, also called the Standard Operating Step (SOP). Its purpose is to define procedures and tools, and establish risk prevention measures involved in performing tasks related to maintenance activities on energized networks and lines in contact with the single overhead basket, that is, specifically designed for work performed on live lines.

This document describes 123 tasks according to the objective of each operation, the number of electricians involved, the tools/equipment and PPE required, potential risks, and the operational steps required to complete the task. These operational steps are described by indicating the gestures and actions that must be performed during the task.

In the case of the company studied, the work is performed in pairs – one electrician performing the task is positioned in a truck under the aerial basket, and another electrician is called a "lifeguard." The latter must remain on the ground, observing and alerting the performing electrician to the potential risks involved in the actions performed. Personal protective equipment (PPE) includes reflective clothing; flame-retardant clothing; a balaclava; a cap; various types of insulating gloves; an insulating sleeve; a helmet; a parachute harness;



boots; and other protective equipment. Collective protective equipment includes barriers and signage with cones and tape, automatic reconnection interlocks, and other equipment (Gemma et al., 2022).

The SOP for the Vegetation Pruning task, for example, whose purpose is to perform tree pruning in distribution networks using specific tools, indicates that the operational step consists of (Traldi, 2022):

- a) Perform preliminary or basic tasks: which involve driving and positioning the vehicle, preparing the Risk Prevention Analysis (APR), signaling the vehicle, signaling and delimiting the work area, checking or inspecting the pole/structure and operating the aerial basket;
- b) Visually inspect: analyze the work situation in detail, articulate its planning and re-identify the possible risks of the operation;
- c) Carry out pruning;
- d) Undo the preliminary tasks.

Prescriptions are considered fundamental for guiding the work to be performed. The concept of task, as defined by Activity Ergonomics, demonstrates how this becomes an important framework for workers, especially in work involving risks, given that the task seeks to anticipate situations and outcomes under specific conditions (Gemma et al., 2021).

Workplace prescriptions aim to facilitate the worker's understanding and execution of work, as they describe the set of gestures to be performed chronologically in a given context. The idea is to create conditions for the worker to have greater control over their actions, thus enabling them to predict cases and situations in which accidents may occur.

However, as also explored by Activity Ergonomics, it is observed that in the workplace, tasks are not sufficient for work to be carried out satisfactorily. Because work is dynamic and unpredictable, it requires individuals to adapt to ensure quality and safety (Gemma, Abrahão, Traldi, Tereso, 2021). The ELV work, observed from a real-world perspective within this perspective, highlights situations in which violating standards has become essential, especially for accident prevention.

5. LIVE WORK ON THE LIVE LINE

The analysis of real work, that is, of what is effectively done based on the physiological and psychological mobilizations of individuals in real work conditions (Guérin et al., 2001), demonstrated that aspects or actions not covered in the POP but executed and developed by



ELVs on a daily basis become exactly necessary and fundamental for work in which quality prevails and, above all, the safety and health of workers in preventing accidents.

First, it's worth mentioning the need for ELVs to prepare the truck at the end of the route for use the following day. Although this task wasn't included in the Operations Manual, electricians considered it essential to replace used parts and organize tools in the truck's trunk. This is because, although they had advance access to the tasks they would perform throughout the day, each task had several subtasks, which required the use of different tools (Gemma et al., 2022).

In this case, the truck's compartments needed to be loaded with materials and resources that could be used regardless of the task at hand. This is because, as they left the fueling station in the morning, they only returned to the site at lunchtime or at the end of the route. Although a simple and quick task, failure to complete it resulted in constant returns to base to search for missing parts, increased task time, and increased fuel consumption. Beyond the organizational advantages, considering a job with a high degree of hazard, using improvised tools or parts not only fails to guarantee the quality of the work, but also jeopardizes worker safety (Traldi, 2022).

Regarding the variability of work situations within the same task (Abrahão et al., 2009), it was observed that this work, in addition to the physical strain on the upper and lower limbs caused by consecutive tasks that take up to 8 hours to complete, also incurs significant cognitive strain. This is because, although the ELVs perform individual and collective planning for the "foot of the pole" task, which also involves the Risk Prevention Analysis (RPA) present in the SOP, as the operator is lifted by the aerial basket and approaches the work situation, new adjustments and adaptations are necessary to perform the task.

For example, the team receives a work order to perform oil switch maintenance on a city pole. The APR, as well as the team's individual and collective planning on the ground, takes into account the need to repair the oil switch. Upon being lifted by the basket and approaching the work site, the electrician in charge identifies that the switch is attached to a hollow wooden crosspiece. While the exterior appears in good condition, the interior is rotten and at risk of falling. This means that, in addition to the switch maintenance, the crosspiece will also need to be replaced. This adds to a task that was previously unscheduled by the operator and the operations center.

A task observed from a visual distance is different from one observed from close up. As presented and observed in Traldi's (2022) research, it is quite common for new difficulties or



subtasks to be added to the structure given the approximation of the work situation, given several other variables, such as: types of poles and crossbars, variation in structural degradation or failure, materials and parts available for the work, crane truck positioning depending on street conditions, pedestrian and vehicle movement, noise from trucks, tools, and roads, and varying weather conditions (work needs to be interrupted in rain or strong winds), among others.

The constant emergence of new variables makes the work even more complex, as replanning actions requires considering the scenario reinterpreted by the operators, the materials and tools required for the new execution, what was initially planned with the lifeguard and other electrician(s) involved, and their own safety and the safety of others, in a context of high risk due to the very nature of the work. For the ergonomics of the activity, the development of situated cognition (Abrahão et al., 2009)—that is, the ability to process information in a given context and define actions based on it—becomes quite complex in a job with significant stress like this.

Still on the subject of ELV work and its relationship to safety, the Preventive Risk Analysis (PRA) document is considered in this case study. While this is a highly important tool used by the company to enable workers to conduct a prior and in-depth assessment of potential risks involved in a project or work activity, it reinforces the predominance of technical strategies in preventing ELV accidents. This is because it only considers visible problems and situations that can be anticipated.

An example of this observed during the research was the implications of high temperatures for the health and safety of ELV workers. High temperatures are a constant in the work studied, and the contextual variability of the work environment in relation to this aspect becomes broad, especially because the tasks are performed outdoors, at different times of the day, different times of the year, for different durations, and involving varying physical, cognitive, and emotional stress. The APR, while important, does not consider the variability and consequences of such conditions throughout the workday—that is, the actual work (Guérin et al., 2001), as evidenced by the case of an electrician who developed discomfort during the research.

Likewise, the company's Occupational Health and Safety Guidelines and the Standardized Tasks Manual, as prescriptions, did not specify the need for hydration or breaks during the workday, important strategies considering the implications arising from the exhaustion inherent in this type of work. Breaks during work are also not provided for in organizational regulations. However, during field observations, it was observed that electricians



took short breaks as their pairs or teams felt the need due to the pace of work and the incidence of muscle fatigue or other symptoms.

Ergonomics, by analyzing these forms of transgressions committed by workers, demonstrates how they develop ways to adapt to work and adapt prescriptions to the organizational, physical, and cognitive variability of work to ensure quality, health, and safety (Gemma, Abrahão, Traldi, Tereso, 2021). In addition to individual strategies such as those identified and cited, Traldi's (2022) research also presented a type of collective strategy that is extremely important in the work of VLEs, which involved a collective work intelligence. The synchronicity in how they performed work activities revealed a practical intelligence, unique to the group studied.

6. SYNCHRONICITY: INTELLIGENCE AT WORK IS FUNDAMENTAL FOR ACCIDENT PREVENTION

Activity Ergonomics traces back to another fundamental concept for understanding work: practical intelligence. Practical intelligence can be defined as the "ability we all have to create, to solve problems beyond the prescribed" (Antipoff & Soares, 2021, p. 379). In other words, it is a type of knowledge developed as individuals encounter task constraints and create solutions to perform their work satisfactorily. According to the authors, workplace intelligence is not associated with cognitive aspects, but rather a wisdom of the body, rooted in the ability to perform work with mastery, dexterity, and fluidity.

In this context, a type of practical intelligence was observed developed by ELVs to deal with the technical and human variability present in the tasks being carried out and followed according to the standard step.

The synchronization of the electricians' actions under the aerial basket to carry out activities, whether individually or in teams – given that a task sometimes requires the work to be carried out by two pairs of electricians, positioned in two crane trucks –, already observed in Traldi, Heloani and Gemma (2023) and in Scopinho (2002) in the work carried out in the electrical sector, is a type of skill that allows the worker to intuitively coordinate the body in order to avoid contact with energized wiring.

This allows both electricians to precisely adjust the height of the baskets and their upper limbs during teamwork, enabling assertive communication with other members of the pair or team. But this doesn't just apply to the body. In addition to coordination over gestures,



synchronization between the electricians allows for proper management of the movement of the cranes and the aerial basket in relation to the operation with the pair. For ergonomics, this entire course of action is preceded by situated cognition—an articulated way of interpreting current situations and formulating strategies to solve and anticipate problems (Abrahão et al., 2009).

This is crucial because individuals work on the same network and live wiring. This also applies to the lifeguards positioned on the ground, who guide and coordinate the simultaneous actions performed in the baskets. While they remain vigilant about work on poles or trees to alert the electricians performing the work to potential risks, they also monitor whether pedestrians are respecting the protected area, the approach of customers inquiring about the operation, the wind direction, the possibility of tree trunks and branches falling on cars or roofs, and other factors that affect daily work situations.

In addition to synchronization between the pairs—executor and guardian—synchronization is also required between teams when performing the same task with two or even three trucks. The larger the team, the more complex it becomes to achieve synchronization, as it involves a larger number of people to organize and coordinate operations. Although they can complete the task in less time, teamwork also becomes complex from a group planning perspective. Discussed planning among team members prior to the start of the activity requires individual intelligence efforts in a collective endeavor to bridge the gap between the prescribed and the actual. In a group, the experience of veteran electricians versus novices influences the alignment of problem-solving strategies, based on knowledge developed throughout their careers.

The practical intelligence developed by these electricians enables them to invent and create resources to minimize task constraints and achieve their objective. More than that, it is fundamental for analyzing and preventing risks and preserving their lives and those of their partners. This involves not only the development of individual but also collective situated cognition, which entails even greater complexities in articulating the know-how of pairs and teams (Traldi, Heloani, Gemma, 2023).

Not surprisingly, the live line category represents the pinnacle of an electrician's career within the company, requiring years of experience with dead (de-energized) lines, job profile assessments, theoretical courses, training in a controlled environment, and gradual immersion in live line electrician teams until the acquisition and development of practical intelligence. At



the same time, it's not the courses and training that fully develop this intelligence, but rather the individual and collective work experience.

Especially in this case, the creation of a group that establishes a relationship of trust becomes fundamental for the development of intelligence at work (Dejours, 2012). The research by Traldi et al. (2023) and Scopinho (2022) corroborates this perspective as it discusses exactly how synchronicity, also observed, is reflected in acts of solidarity and the feeling of belonging and collective work, becoming fundamental for the preservation of workers' safety and health.

7. FINAL CONSIDERATIONS

Given the above, the importance of Activity Ergonomics for analyzing work in hazardous situations, especially the work of live line electricians (LCE), is evident. This approach's potential for analyzing work in its determinants and in a situated manner allows us to understand the actual work of these workers, the human and organizational variability present in work situations, and to highlight the individual and collective strategies and operating methods employed. These elements reveal how the articulation of these aspects allows electricians to perform hazardous work with quality while preserving their health and lives.

It is also noteworthy how the practical intelligence of the ELVs gains a distinctive expression in the methodology adopted here, allowing for a broader understanding of this inventive approach and shedding light on a more complex understanding of workplace accident prevention in high-risk activities. By considering the perspective of the social actors involved in work and the variability present in the workplace, it reclaims the potential for a systemic approach that challenges traditional models of occupational safety management and analysis.

It is important to add that the application of AET in high-risk work presents additional challenges, since the need to ensure the safety of both researchers and workers can limit the depth of analysis in certain situations and the interaction with them.

Considering these aspects, it is understood that live work on the live line could only be viewed in a broad and integrated way through the ability to explain the reality of work, which is so important for Activity Ergonomics.

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