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THE CONTRIBUTION OF WORK PERMITS TO SAFETY: THE CASE OF A THERMOELECTRIC PLANT

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Summary: The Work Permit (PT) process is a system widely used in high-risk industry to achieve high levels of safety. It is inserted in several activities within companies, but it is in the dialogues and interactions between Maintainers and Operators in the field that its purpose becomes evident. This article aims to highlight the relationship between PTs and safety and respond to the demand about the efficiency of this process in a thermoelectric unit. For this, a case study is used that uses Ergonomic Work Analysis (AET) as the main data collection and analysis tool. The PT is identified as a document that, in addition to helping to prevent risks, creates an opportunity for reflection before the activity, thus contributing to the safety and integrity of the facilities. Furthermore, the study highlights three main deficiencies related to this process at the unit: i) high volume of documentation and requests in the field; ii) failure in communication with lack of pertinent information; iii) Low room for maneuver in a complex environment. Finally, such issues are analyzed using the literature raised, providing support for their discussion with the company and the study group, thus favoring an improvement in this process and its function in relation to safety.

Keywords: Work Permit; Security; Ergonomics.

1. Introduction

This article addresses the contribution of Work Permits (PT) to increasing safety in a Thermoelectric Power Plant (UTE), using concepts from the ergonomics of the activity. The focus is on the activities of operators and maintainers, highlighting their influence on the overall safety of the unit. It is worth mentioning that this work is carried out within the scope of an ongoing research project, which aims to develop a methodology for the integration of Human and Organizational Factors in Industrial Safety (FHOSI).

Over time, the concept of job security has been intrinsically intertwined with the history of human work. Based on the broad concept of health, occupational safety represents a multidisciplinary approach and strategy aimed at eliminating or reducing the risk of accidents during the performance of professional activities (Figueiras; Scienza, 2021).

Therefore, according to Assunção and Lima (2003), the ergonomics of the activity aims to study the modification of working conditions, aiming to increase the reliability and safety of systems, in addition to preventing work-related damages. In this way, it is based on knowledge about human beings in activity, simultaneously considering their physiological, cognitive and social dimensions (Falzon, 2018).

This multifunctional perspective raises several relevant questions related to the well-being of workers and the performance of activities. Among them, some studies point to the relationship between fatigue and temporary loss of efficiency (Falzon; Sauvagnac, 2007); the crucial role of the cognitive aspect in understanding the situation and making decisions (Hoc, 2007; Antipoff; Soares, 2021) and the importance of communication in order to have good coordination and sharing of information (Karsenty; Lacoste, 2007).

Furthermore, with regard to safety aspects, standards, rules and procedures play a fundamental role in guiding actions in the field. Generally, such guidelines incorporate past experiences, scientific knowledge and current legislation, aiming to prevent unwanted occurrences in the future (Rocha; Vilela, 2021). In this context, the Work Permits (PT) process stands out, which is a system widely used in high-risk industries to achieve high levels of safety, with an emphasis on isolation, which is a safety precaution that aims to restrict the access and exposure of individuals to potential risks and hazards in a specific location.

The Health and Safety Executive (HSE) (2005), Britain's national regulatory body for workplace health and safety, defines a work permit as:

> "A work permit system is a formal, registered process used to control work that is identified as potentially hazardous. It is also a means of communication between site/facility management, plant supervisors and operators and those carrying out dangerous work" (HSE, 2005, p. 7, our translation).

This article presents a case study carried out in a UTE whose evidence collection methodology is Ergonomic Work Analysis (AET), aiming to highlight the relationship between PTs and safety, seeking to respond to the demand about the inefficiency of this process in the unit. operational and its impact on maintaining the integrity of the facilities.

1.1. Features of the Work Permit process

For the objectives of the Work Permit to be achieved, there are some challenges in its operation. Andrade (2016) points out that some of them are: "allowing the adaptation of the planned PT to the reality of the context in the field, and facilitating different teams to have the same knowledge of the work, its risks and the current situation of the PT." (Andrade, 2016, p. 32). Furthermore, Iliffe et al. (1999) elaborate three distinct functions for which the PT system should be responsible.

> "Firstly, they help in identifying potential hazards along with the concomitant precautions that must be taken; second, they help coordinate the imposition of precautions, the effective execution of the maintenance task, and the eventual removal of precautions. Third, they provide a written record of what was done, by whom, when and how." (Iliffe et al; 1999, p.70, our translation).

Another challenge discussed by Ramiro and Aísa (1998) is the effective appropriation of PT performers. The author shows that it is common for workers to just read the description of the work to be done, since most tasks are routine and the content of the permissions is similar. Furthermore, current systems assume that document issuers are competent to identify risks, however this is not always valid due to the high complexity of the modern workplace (Iliffe et al., 1999)

Still due to the complexity of the systems, another point is that PTs should not be immutable. This issue is highlighted by Iliffe et al. (1999), who state that PTs must be easy to modify to meet the circumstances and needs of workers, and must also be specific to a given plant.

In his study, Souza (2013) points out the PT activity as the one that consumes the most time during the operation technicians' work shift. In this sense, Ramiro and Aísa (1998) state that it is advisable for the PT issuer to accompany the worker to explain the main risks of the activity, as well as at the end to check what was carried out, collecting the signed document. Considering these issues, the importance of sufficient time for checks, the HSE (2005) highlights the number of PTs that a single issuer can manage as limiting. Therefore, the simultaneity of critical activities can have negative consequences for the cognitive process necessary to carry out the activities (ICSI, 2021).

Finally, Andrade (2016) concludes by stating that it is not in its rigor that PT guarantees the safety of activities, but rather in the dialogues and interactions between actors who discuss the safety factors located in a service.

1.2. PTs in the context of the Oil, Gas and Energy industry

In the Oil and Gas Industry, Work Permits constitute a significant part of the activities, being a process included within the broader maintenance segment, which includes work planning, release with the participation of different actors, support for execution and discharge from work (Andrade, 2016). In this sense, accidents recorded in this sector in recent decades have revealed inefficiencies in this system for supporting safety (Atherton; Gil, 2008).

One of the most prominent was the explosion and fire that occurred on the Piper Alpha offshore oil and gas platform, whose analysis showed failures in the PT system, poor hazard analysis and inadequate training in safety procedures (Jahangiri et al.; 2016). After the accident, several lessons to be learned were drawn up. Appleton (2001) presents, as one of them, that the PT system must involve a safe method of locking valves to prevent inadvertent openings, demanding a systematic assessment of all potential dangers and interactive effects.

In addition to the aforementioned accident, there were still others in which PT appears in the analyses, such as at BP Grangemouth (UK, 1987), at Shell Port Eduoard Herriot Depot (France, 1987), at Phillips Chemical Company (USA, 1989) and at Motiva Enterprises LLC (USA, 2001) (Atherton; Gil, 2008). Some of the main points highlighted by the analyzes of these events highlight failures in communication between teams, the need for greater attention to changes that may occur in the workplace during the execution of the activity, lack of information about the job description and risk assessment with insufficient on-site checks.

1.3. The Research Method

This study follows the steps of the Case Study proposed by Yin (2015), seeking to investigate a contemporary phenomenon in its real-world context. To achieve these objectives, the following steps were carried out: planning, design, preparation, evidence collection, evidence analysis and reporting.

In the planning stage, it was defined that, to achieve the objective of the study, an exploratory and descriptive case study would be carried out, which aims to fill the gap in previous studies on the energy production industry and present interpersonal situations and their key phenomena . In this context, it is worth highlighting that the selection of this pilot unit in question was made by the oil and gas company itself, which defined which units would participate in the FHOSI project. Furthermore, the development of the PTs process appears as a demand to improve the unit's safety performance, with workers' participation being voluntary, following workers' confidentiality procedures.

In the design stage, a literature survey was carried out to delve deeper into the topic and study questions. A Brazilian thermoelectric unit was used as the research object. The choice was influenced by the fact that it is an old unit that, to ensure the reliability of equipment and installations, requires a high number of daily maintenance tasks involving the PT process.

In the preparation stage, the research protocol was developed. It was defined that the evidence collected through an Ergonomic Work Analysis (AET), a method that uses open observations and verbalizations with workers to construct a diagnosis of the situation. This method proved to be suitable for contributing to the understanding of the work and the logic of using the document.

In the evidence collection stage, direct observations of typical work situations and open interviews with workers were carried out (GUÉRIN et al., 2001). The data collected was demand-driven, with the AET process following three central steps: (1) exploring the functioning of the organization, (2) understanding the work permit process; (3) systematic observations of the activity, followed by open interviews; and the formulation of analyzes and notes.

Studies of the organization's functioning were carried out through fortnightly remote meetings with the different sectors of the company between March and November 2021, in addition to a three-day visit to the unit (01/12/2021 to 03/12/2021) to knowledge of facilities and recognition of key sectors and activities of workers. The analysis of the activity, in turn, considered 8 visits to the thermoelectric plant, in a total of 21 days in the field. During these visits, 7 work situations involving work permits were observed. In this article, two cases were selected, one round with a production operator who released PTs and one monitoring maintenance service, with these activities directly impacted by the PT process. These systematic observations are structured in chronicles of activities that allow observing the observed variables (Guérin et al., 2001), and complemented with open interviews to broaden the understanding of the challenges and problems faced by workers in their tasks, using the approach known as self-confrontation (Mollo; Falzon, 2004).

The analysis of the evidence is presented in the discussion chapter, in which the technique of theoretical propositions (Yin; 2015) is used, deepening the analyzes and diagnosis, comparing what was observed with the discussions held with the teams and the literature on the topic of work permits.

Finally, the reporting stage is presented in the next section of this article and constitutes the result of the research.

2. Development and Results

2.1. The functioning of the organization

The UTE's main inputs for its production process are natural gas and water, and the plant operates in an open cycle with gas turbines operating in isolation, that is, the gases are discharged into the atmosphere after passing through the turbine and are not reused, so thermal efficiency is reduced. The amount of energy demanded by the unit is reported daily by the Integrated Operations Center, with priority given to departures organized by the unit. It is important to note that the turbines are not requested to be in continuous generation, and what is offered by the UTE is their availability for generation on demand.

Another relevant point for the operation of the unit is the understanding that, although it has a strong in-house workforce, the plant's maintenance is outsourced. Table 1 briefly presents the work teams most related to the PT process.

Table 1: UTE Teams

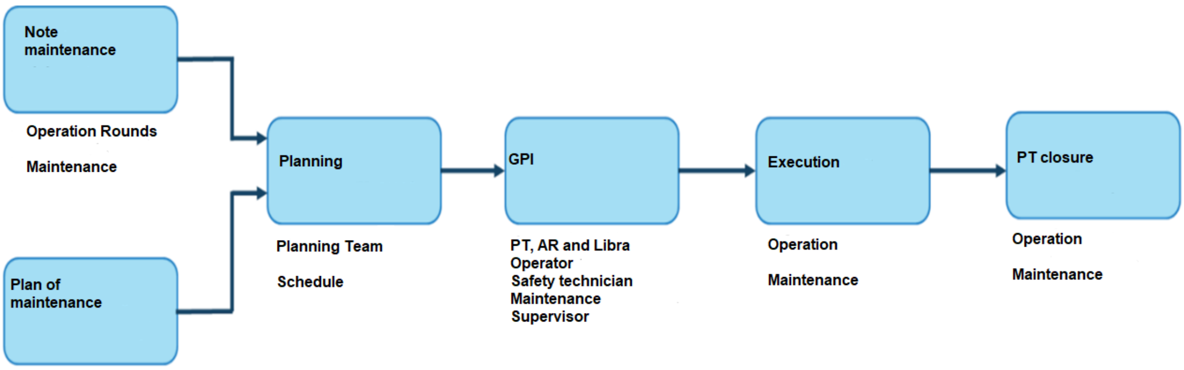
Maintenance	Operation	Planning
The Execution team is outsourced and includes specialists in various areas, each with its own field inspector and a team of executors. The person in charge of each specialty carries out risk analyzes in collaboration with Planning.	It is made up of five operators per shift, including a supervisor, a panel operator and three field operators, and at night, the number is reduced to four. Its main activities are the start-up processes of generating units and the release of PTs in the field. In addition, they carry out rounds to check the functioning of the unit.	Responsible for preparing Maintenance Orders (OM), in addition to organizing the weekly schedule of activities. The occupational safety technician and an operator prepare documents such as PTs, Risk Analyzes (ARs) and LIBRAs (A Release, Isolation, Blocking, Racketing and Warning system). These documents are collected by the person in charge and distributed to maintenance performers.

Source: The Authors, 2023

2.2. The PTs process in the unit

To understand the stages and teams involved in the PT process, Figure 1 presents a simplified diagram of its stages, along with the main teams involved in each of them.

Figure 1: Simplified model of the PT process



Source: Pereira, 2022

The process can be initiated in two ways: opening a maintenance note (NM) by a maintainer or field operator; or through the unit's maintenance plan. The planning team prepares Maintenance Orders (OM) pointing out what will be executed, what safety procedures are necessary, what is foreseen by the standard of that activity, what is included in the maintenance contract, the necessary tools, the sizing of the team and the time required to perform the service. The planner for each specialty is also responsible for preparing the weekly service schedule.

With the OM and the weekly schedule, the Integrated Planning Group (GPI) is responsible for preparing the documentation for PTs, ARs and LIBRAs. There is also a schedule of days/times in which those in charge of maintenance for each specialty must attend the GPI to prepare the ARs, and the PTs are prepared the day before the service is carried out. To this end, the software is used to request, prepare, issue, close, cancel and audit the PT. Another relevant point is that the AR number is included in the PT, so that if there is a review in the risk analysis with a change in number, the corresponding PT needs to be canceled and another issued. There is no procedure for reviewing the PT after it is issued, and any adjustment requires canceling the document and issuing a new one.

After the documentation is ready, on the day of the service it is the responsibility of a field inspector (third party) to collect the day's PTs in the control room and divide them between the maintenance specialties for execution. Release and closure must take place in the field close to the service location, being signed and supervised by an operator.

2.3 Systematic observations

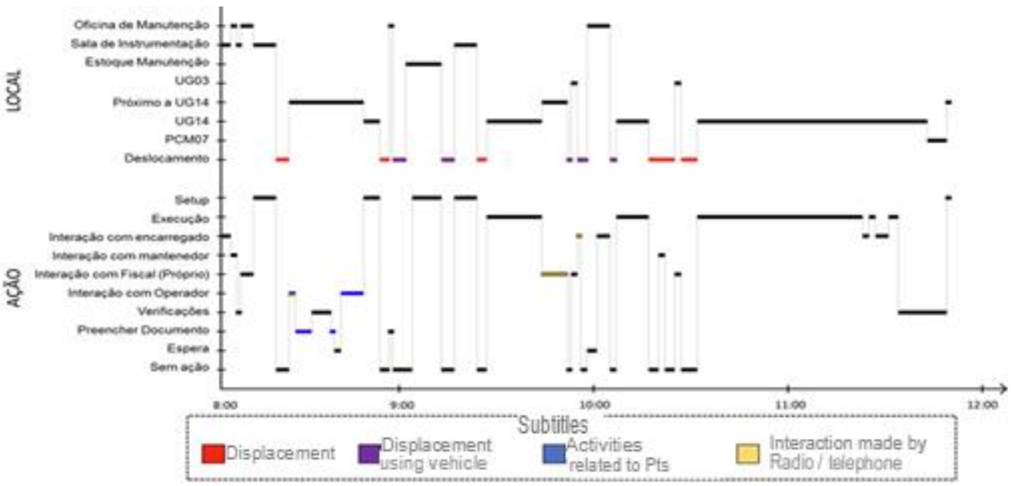
According to the AET methodology, two situations were chosen for systematic observations: one related to maintenance and the other to operation, aiming to provide an understanding of the real activity of these professionals and the way in which PTs are incorporated into their routines.

2.3.1. Instrumentation team activity: Gas valve inspection

The observation by the instrumentation team occurred during the corrective maintenance activity on one of the turbines, regarding a trip due to a gas valve failure. This valve inspection and repair was outside the schedule, but was requested to be included on this day. An observation made by the person in charge is that, in addition to this PT, there was another preventive maintenance activity scheduled on another generator that day, but it will not be carried out since the generator of this unit, on which the service would be carried out, is out for maintenance “It was supposed to be released, but it isn’t, so it keeps accumulating”. (Instrumentation Manager).

Graph 1 represents the chronicle of the activity monitored and then there is a description of the main points of this monitoring. The chronicle is organized with observables: Location and Action. There are several interactions with the maintenance inspector and the person in charge of decision-making, in addition to constant travel, including the need to use a vehicle at times.

Graph 1: Chronicle of Instrumentation Activity



Source: Pereira, 2022

Upon receiving the PT, the technician, together with the person in charge and the inspector (himself) interact to understand the history of that proposed service. This does not generally occur in preventive maintenance, where teams usually already know what to do. This corrective PT comes from an old OM, with the following record: “During operation, the unit alarmed a ground fault in the battery charger, causing a failure in the gas valve supply, which subsequently tripped”. Upon obtaining this information, the person in charge of instrumentation comments “they must have resolved it in the emergency, but it was recurring and they took advantage of the text of that old OM”.

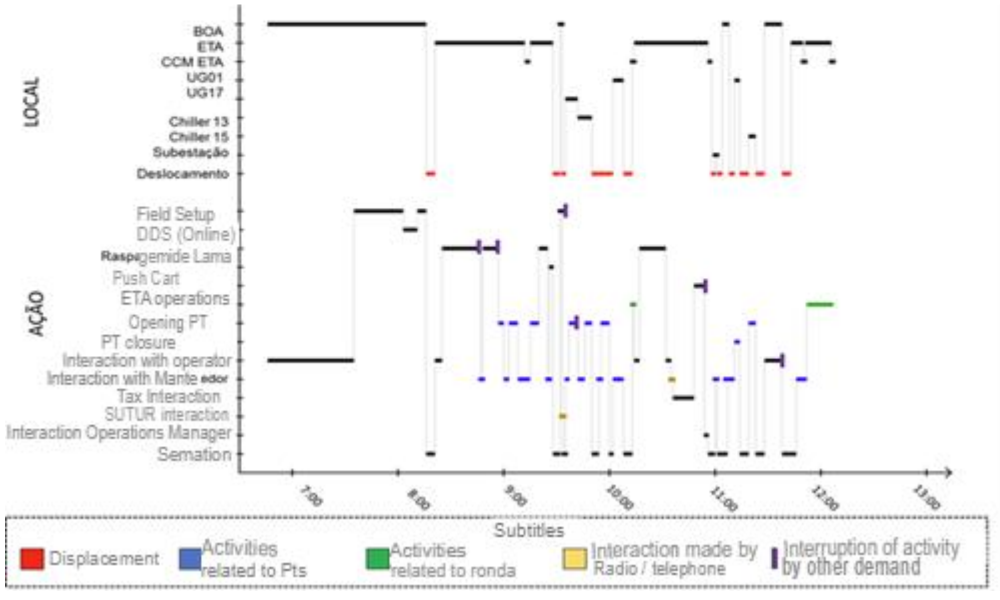
Upon arriving close to the area of the generating unit where the activity will be carried out, the technician calls the operator via radio to open the PT and while he waits, he fills out the documents and places his padlock in the red LIBRA box. At that moment, the worker states “paper counts a lot here”. When the operator responsible for the block arrived, he checked the tools together with the technician, and filled out the PT using the paper and the Personal Digital Assistant (PDA). During the execution of the task, there was a need to use tools that were not with the material taken, requiring a trip to the outsourced company's internal stock, which is located in the UTE itself, but in a remote region, as well as another trip to the instrumentation workshop.

In the case of corrective maintenance, an investigation into a valve that has a defect, the maintainer who receives the service started the activity without much information about the case, having to resort to frequent dialogues with the inspector himself and his supervisor, requiring move in search of appropriate and specific tools, while carrying out the work itself. Opening and providing information on the PT document proves to be of little use during the process, adding only bureaucracy to the activity.

2.3.2. One operator work shift

The accompanied operator is responsible for two distinct areas which are located at opposite ends of the industrial area, resulting in a significant need for travel. Graph 2 presents a chronicle of the operator's activity in the morning, followed by some highlights from this period.

Graph 2: Operator Chronicle - Morning



Source: Pereira, 2022

The chronicle allows us to observe the high number of places the operator travels in the morning, showing movements in the passages between the extremes of the operational area. Another issue to be highlighted is that due to the demands that arise in the morning, only part of the round's checks were carried out, leaving its conclusion to be carried out in the afternoon. It is worth noting that during the day the operator was contacted several times by radio, but as these interactions are quick (lasting less than a minute) they are not represented in the chronicle. The content of these interactions is made up of maintainers and operators reporting their positions, to know where services existed, awaiting release. Some relevant situations that occur during the shift are described below.

During service releases in Block 5, the electrical team reports that they were unable to carry out a chiller motor test activity, as the mechanical team had not yet installed it. Therefore, they were redirected by the person in charge to another activity in another nearby chiller. This is a typical situation, in which a service ends up being issued, even if it depends on another, which has not yet been completed.

Another important moment occurs when, during travel, an instrumentation maintainer asks for support to release the PT and remove the LIBRA to perform a measurement. However, when analyzing the service, it was found that there was another mechanical team working within the unit, and that, therefore, the LIBRA could not be removed. He found out that the mechanics team should deliver the work at 2pm and only then could LIBRA be removed for the instrumentation team to work.

During the shift, a situation that causes stress is being called by radio, but when you go to the service location there is no one there. The operator says: “He called, but he didn’t wait on site, that makes things difficult”

Among the service closures carried out on the day, one that stands out is that of the substation, which was not completed and will continue in the coming days. Regarding this closure, it was mentioned: “it was not concluded because there is still more to exchange, but there is no stock, if I were to run the entire substation to check, I cannot, in the procedure I would have to see, but at the substation I ask what was done and close ”. (Operator)

During the transition to the night shift, which took place at 6:30 pm, between day operators and those who arrived, some relevant cases were reported. One of them stated that during the day he removed several LIBRAS without any operation having taken place. When asked why this is, he states that this is a situation that has been occurring quite frequently. “They (maintenance) ask to put LIBRA on, sometimes urgently and it arrives at the right time and there is no person and they don't do it, so they reprogram everything and we remove LIBRA." (Operator).

The group also reports that the high number of opening and closing requests directly impacts the quality of work. "We have, on average, 20 PTs per day who share with the workforce, in the meantime (while opening to PTs) emergencies arise and play for corrective purposes, this impacts preventive measures." (Operator). On this subject, another operator reports:

> "During the day the operator doesn't stop for anything. There's no time left for the technical part, just putting out fires. There is a lot of demand for little labor, both in maintenance and operations. Management does not accept this, a study was carried out and they say that it is enough. Our experience has compensated for this type of thing" (Operator).

3. Discussions

This work was guided by apparent dissatisfaction with the process, which appears in the verbalizations of several workers, generally related to bureaucratization and overload on the team. In this way, based on the cases studied, it is possible to characterize deficiencies related to: i) the high volume of documentation and requests in the field; ii) failure in communication with lack of pertinent information; and iii) a low margin of maneuver in a complex and dynamic environment.

Regarding the volume of work, there is an excess of fronts with which operators interact during their activity, confirming Souza's (2013) observation about the PT activity being one of the most time-consuming activities for operators. Through monitoring, it was possible to notice the high rate of requests in the field, with the opening of services with PT being one of the most constant. This volume can mean a loss of more effective investigations and time to actually interact with maintenance teams, as it is "the simultaneity of several critical tasks, which divides the attention of operators" (ICSI, 2021, p 9). In this sense, Hoc (2007) reaffirms that it is necessary to build a cognitive commitment to understand the situation and decide to take action.

> "Understanding often extends over an extensive temporal range, in parallel with decision processes with a minimum level of understanding to keep the supervised process under control" (Hoc, 2007, p. 447)

This scenario also leads to operator fatigue, due to the physical effort of having to move between UGs, and cognitive, generating a loss of efficiency in identifying risk situations

(Falzon; Sauvagnac, 2007). Furthermore, Antipoff and Soares (2021) discuss how attention, another cognitive process present in the activity, plays a fundamental role in decision-making during the activity.

The loss of PT's main purpose in this situation still stands out, which would be the creation of collective spaces for discussion to treat PT and monitoring the activity that conceives the work task and its adaptation to the field, as highlighted by Ramiro and Aísa (1998) and Andrade (2016).

The case of maintenance highlights the issue focused on communication, which, according to Karsenty and Lacoste (2007), must ensure the coordination of decisions and the sharing of information. In this sense, it can be seen in the activity accompanied by the instrumentation maintainer, a high workload in searching for information on the machine's history so that he could understand what needed to be done, in addition to travel to search for materials identified as necessary only after the start of the activity. In such situations, the PT ends up not fulfilling one of its functions of helping to coordinate the precautions of the activity and its execution (Iliffe et al., 1999).

The third issue raised about PT processes concerns their lack of flexibility. During discussions with workers, it was noted that there is no possibility of review. Any necessary change, including in related documents such as AR or LIBRA, results in the cancellation of the current PT and the requirement to start a new process. This aspect was pointed out by Iliffe et al. (1999) as one of the weaknesses of the system, since in essence, PT should enable relevant discussions and allow modifications to meet the needs of workers in different circumstances.

4. Conclusions

This article demonstrated, through two situations analyzed from an ergonomic perspective, deficiencies experienced by the operation and maintenance teams of a UTE during their activities engendered by the current PT process. The main function of the PT document is to create an opportunity for reflection, as it is precisely the perception of risks and their reflection that can prevent the occurrence of serious accidents and the overestimation or underestimation of existing risks. Thus, the merely bureaucratic document loses its function and distracts the team from what really needs to be questioned. At this point, Daniellou and

Béguin (2007) reaffirm that the difficulties for the operator are not limited to what is done, but also to what he would like to do, but cannot.

The limits encountered during the preparation of this work include the high number of relationships that the PT process has with all areas of the company, representing a series of possibilities for further development. Furthermore, ergonomic action requires building practical solutions together with the unit. It should be noted that this work is inserted in the context of an ongoing research project, FHOSI. This is a project that foresees in its final stage the construction of transformation actions that will be monitored by researchers, so the present study intends to provide subsidies for their discussion and elaboration with the company and the study group.

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