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Abstract

This work focus on the creation of two safety procedures, concerning a safety regulation for service providers and a permit-to-work system, in the facilities of a company specialized in the transformation of oilseeds into flours, vegetable oils and biodiesel.

Regarding the service providers' safety, an analysis was made to the current legislation and to the methodology used by the company for the approval of this kind of workers and for controlling the documentation which the companies are obliged to deliver. Therefore, a file for an automatic documentation control and service provider's approval was produced, as well as a safety regulation, in which it was included the new service providers' approval methodology, emphasizing the workers' categorization concerning the risk they are exposed to, the formalities of the work and the safety rules that must be abided in the facilities. Furthermore, there were lobby records which were computerized and road circulation flyers that were created, to be delivered to suppliers and/or shippers. The documentation control file and the lobby records were tested and the suggested improvements were applied.

Concerning the permit-to-work system, after analyzing the statistics and causes of work accidents in the company, a work instruction was produced, explaining how the system works, as well as the process flow leading to the issue of the permit-to-work declaration. A permit-to-work declaration was also created according to the company needs.

For both procedures, an implementation plan was studied.

Keywords: Industrial Safety and Hygiene; Management Systems; Safety Procedures; Work Accidents Analysis; Permit-to-work; Service Providers' Safety

1. Introduction

Since the industrial revolution, the technological development has been constant in every industry, especially when it comes to process optimization and automation. The pressure inputted by stakeholders, concerning competitiveness and product quality, has demanded several investments in the continuous improvement of industrial processes, in a way that reduces costs and, therefore, enlarges profits.

From this concern, and given the historic of industrial accidents in the XIX and XX centuries, Industrial Safety and Hygiene arises as a way to manage industrial risks and to minimize the derivate costs from industrial

accidents. Despite not being well received at the beginning, this area became extremely important for companies, turning into one of the main vectors of organizational management.

When it comes to management, Safety Management Systems (SMS) aim at the implementation of theoretical concepts from the multidisciplinary area of Industrial Safety and Hygiene in a company, adjusted to its reality.

Despite their importance, SMS are not usually the first management system implemented at a company. Historically, the Quality Management System is carried out first, followed by the Environment Management

System and the, finally, the SMS. Often, the three management systems are integrated in one management system.

The company where this study was carried out during 6 months (which, from now on, will be named COMPANY), long ago defined a politic that invested in the continuous improvement of its Environment, Quality, Safety and Sustainability Integrated Management System, showing the commitment to develop a safety culture in the COMPANY and, therefore, improving the work conditions.

The COMPANY started its operation in the 60's producing soy oil and soy flour. Throughout the years, the process capacity was enlarged several times; however, there was overproduction of soy oil, in 2003, as an outcome of the increasing demand of soy flour. Consequently, the executive committee invested in a strategic alteration and the COMPANY started to produce biodiesel from the surplus soy oil. In 2009, a European Directive (2009/28/CE) came out, stating that biodiesel had to be added to diesel, making biodiesel the COMPANY's main product.

The current Environment, Quality, Safety and Sustainability Management System in the COMPANY was implemented following a top management strategic alteration. This alteration was done in order to have a bigger unification of the COMPANY's vision with the management of the integrated system. This new Integrated Management System is certified by the standards EN ISO 9001:2015 and EN ISO 14001:2015.

The COMPANY's commitment is to properly train workers to perform their tasks safely and correctly, to follow high quality standards, protect the environment and to follow all regulation. There is also a high commitment to continuously evaluate and improve this Management System, specifying their goals and the means to achieve them.

To evaluate the possibilities to improve their Management System, the COMPANY does a statistical analysis of their work accidents. The COMPANY uses three indexes to help this analysis: frequency, incidence and severity indexes. The first one is defined as the number of accidents *per* million hours of work that lead to a sick leave. The incidence index is defined as the number of accidents *per* one

thousand of workers. Finally, the severity index is defined as the number of days of sick leaves by every million hours of work.

In the COMPANY, this analysis has been done since 2004. The data from 2004 to 2016 is displayed in the Picture 1, Picture 2 and Picture 3.

It is possible to observe a notorious tendency in the frequency and incidence indexes, resulting from implementation of a safety policy, as well as monetarization of risk's behavior. However, the severity index shows a high level of fluctuation. Since 2010, the index showed a tendency to decrease, only interrupted in 2014, where it increased by 3,8%, when compared to the previous year. In 2015, a serious accident with a heavy machine led to a 365 days sick leave. This accident caused an increase of 144% in the value of the severity index, when compared to the 2013 value.

In order to have a deeper perception of the accidents, a study to the work accidents of 2016 and 2017 was made, when it comes to the type of worker involved in the accident (internal or external) and the causes of the accident.

The analysis to the type of worker involved in the accident can be observed in the Picture 4 and Picture 5. It is seeable that in 2017, until August, 9 accidents had happened, 5 of which were suffered by external workers, making it 56% of all work accidents. In 2016, there were 25 accidents, from which 6 involved external workers (24%).

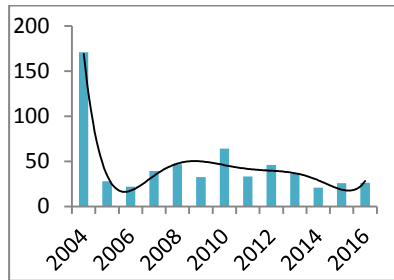
In 2017, 8 of the 9 accidents did not lead to a sick leave. 6 accidents were solved resorting to first aids and the other 3 needed medical assistance. There was no record of the sick leave duration for the most serious accident.

In 2016, 17 of the 25 accidents were solved resorting to first aid. From the 8 that needed medical assistance, 7 needed sick leave days. There was also a *quasi*-accident, where a worker was hanging from a metallic structure, since the stairs he used to access it was not in safe conditions to be used.

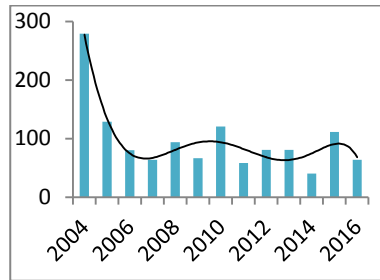
Analyzing the causes of the work accidents from 2016, it is verified that most of them are lack of preparation of the work, wrong or inexistent use of personal protective equipment and wrong risk assessment of risks.

At least 12 of these accidents were caused by either of the stated reasons, as seen in Table 1. There also a severe lack of communication between the workers and the supervisor of the

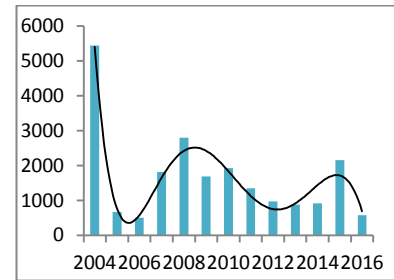
shift. This problem adds even more risk to the operation and contributes to the lack of preparation of the task.



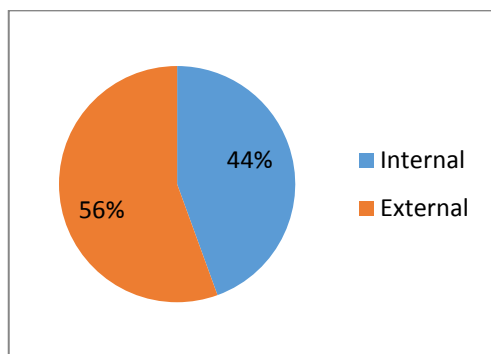
Picture 1 - Frequency Index History



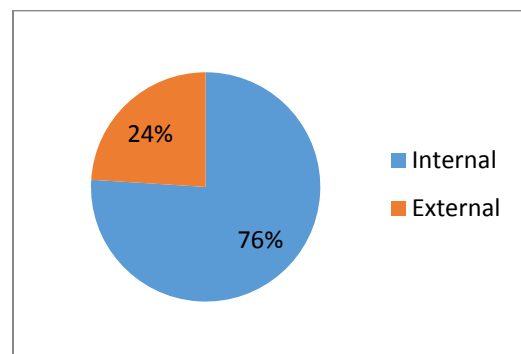
Picture 2 - Incidence Index History



Picture 3 - Severity Index History



Picture 4 - 2017 Accident Data



Picture 5 - 2016 Accident Data

Table 1 - Causes of 12 accidents occurred in 2016

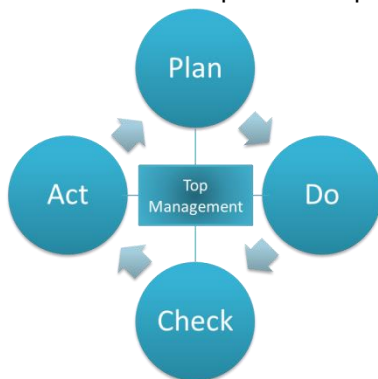
Data	Kind of Accident	Causes
02/02/16	Fall of Material	Incorrect attitude and access difficulty – lack of preparation
04/05/16	Trapping	Improvised use of tool
12/05/16	Muscular strain	Access difficulty – lack of preparation
06/06/16	Muscular strain	Incorrect risk analysis and weight overload
18/07/16	Muscular strain	Incorrect risk analysis
21/07/16	Burn with pressurized hot water	Lack of preparation and Incorrect risk analysis
27/08/16	Burn by contact with hot surface	Lack of preparation and Incorrect risk analysis
02/08/16	Burn with steam	Lack of preparation
05/08/16	Chemical burn	Reckless behavior while driving a truck with an acid load
09/08/16	Burn by contact with hot surface	Incorrect risk analysis and lack of personal protective equipment
23/10/16	Fall	Non-planned work
30/11/16	Trapping	Incorrect risk analysis

2. Methods

A Management System is a structured group of policies, processes and procedures used by a company to ensure the corporate goals' fulfillment, which can be financial success, product's quality, operation's safety, good relationships with clients or legal compliance.

These systems can have several degrees of complexity, considering the business dimension and the established goals. However, every MS is based on Deming's PDCA (Plan, Do, Check, Act - Picture 6), which allows any system to continuously improve itself within the company. However, the Lean – Six Sigma philosophy proposes another step, before initiating the cycle, which composes of an observation of the reality and then planning the necessary procedures to meet the established goals.

After implementing the planned procedures, it is important to check if the outcome is the expected one. If not, some corrective measures need to be implemented (act). Throughout this cycle, the presence of the top management is the core activity to develop the continuous improvement process.



Picture 6 - PDCA cycle

This methodology was followed to identify the points of improvement in the COMPANY's Safety Management System.

2.1. First Phase: Observe

While observing and analyzing the results of the statistical analysis of the work accidents, it is possible to draw some conclusions. First of all, there is a clear problem with outsourcing workers' safety, as they have a big contribution to the number of work accidents in 2016. To go deeper in this problem, the causes of these

accidents were analyzed and it was clear that most external workers didn't know or didn't follow the COMPANY's safety rules, were not aware of the risks or didn't prepare the task correctly. Also, some road accidents involved shippers or suppliers, showing a clear need to develop a strategy to prevent this kind of accidents.

Concerning service providers, there was also a need to improve their documentation management. The control of the legal documentation, was made by sending to the COMPANY by e-mail and saved into the COMPANY's server, after being verified. This method was confusing and inefficient.

Lastly, internal workers also presented unsafe behaviors, much like external workers, in terms of preparation of the work and a correct risk analysis. They also showed reluctance to wear their personal protective equipment, especially helmet and sound mufflers. It became clear that there was a need to oblige the workers, either internal or external, to understand the risks of their tasks and to follow the safety rules. It was also extremely important to improve the communication between workers and the shift's supervisors.

2.2. Phase Two: Plan

To answer the identified problems in phase one, it was necessary to develop a strategy that would, on one hand, correct the unsafe behaviors and, on the other hand, be easy to implement on the worker's point of view.

This way, to solve the problem concerning external workers, to adopted strategy was to develop a new safety regulation, which would be a better fit for these workers than the previous one. This previous regulation, in force since 2003, stated some safety rules, mostly referring to the uses of personal protective equipment. However, this regulation was not up to date, and was mostly directed to construction companies. Thus, this regulation was difficult to apply to smaller tasks. A concerning point was that this regulation was not complying to the current legislation (Law Decree 102/2009, September 10th, according to which, all companies are obliged to manage their service providers' health and safety).

Besides this regulation, an important addition to the external workers' safety was a safety training session, mandatory to every outsourcing worker. This session would consist in a 45 minutes explanation of all the risks and safety rules. These practice was already used in the COMPANY, however, it was clear that there was a need for these external workers to update this session, due to long time they did not work in the facilities.

When it comes to road safety, the solution found was to implement a set of circulation flyers, with previously defined routes. The building organization in the factory leads to dangerous maneuvers, such as U-turns and reverse gears. This way, when drivers do not follow the instructions given by the security, they increase the risk of a road accident for themselves and the other people in the facilities. Thus, this set of flyers were designed to be handed to suppliers, shippers and remaining service providers, in order to make it easier for them to understand the path to follow and, therefore, decrease the number of road accidents in the factory.

In terms of documentation control and management, the best strategy found was to develop a unified file, where the user could easily access and add data, saving time. This file would also simplify the service providers' approval process.

Finally, in order to promote the communication between workers and supervisors in terms of risks of maintenance operations, to increase the Safety-Based Behavior culture among workers and, overall, to increase the safety of all tasks, the planned solution was to develop a work permit system.

2.3. Phase Three: Do

2.3.1. Safety Regulation for Service Providers

It is extremely important that every service provider knows and understands the risks existing in the facilities, as well as the specific risks of their tasks. This kind of workers should be treated as all internal workers are treated, in terms of safety. Some authors, such as Lutcham (1), consider the safety management of service providers on of the biggest opportunities to improve the companies' SMS.

Therefore, the developed safety regulation main points to ensure the workers'

safety were activity planning and task control. The document was divided into two sections, corresponding to the preparation and execution of the work.

First of all, the regulation states that it is applied to every company that is going to do any kind of work, as well as any subcontracted company. It also states what legal documentation should be sent, through e-mail, to the company, following two templates attached to the regulation. A flowchart was added, in order to explain the approval process for service providers is shown, in a way that shows transparency from the COMPANY. Finally, the regulation states the initial rules to start the tasks, such as work hours and the work procedure to be discussed with the coordinator of the job. These rules are important to maintain the safety of the tasks. One of the most important points was the work permit. This work permit is mandatory for every medium/high risk service providers and has to be discussed with the coordinator of the job and the manager of the area where the jib is going to be performed.

Secondly, a series of rules were defined, such as vehicles' circulation, handling of chemicals, inflammable materials and compressed air, tidiness and cleaning of the work area, residues management, handling of equipment and utilities and tasks in ATEX areas.

2.3.2. Road Safety

Concerning road safety, 5 routes were designed (corresponding to all 5 points of expedition/delivery) and added to flyers, to be delivered to the drivers upon entrance in the facilities. A set of rules were also added to these flyers, in order to reinforce the drivers safety. These rules consisted mostly in behaviors to be adopted, such as the use of personal protective equipment, smoking areas and use of cellphone. To complete this work concerning the security and safety of the facilities, and in a way that increased the digitalization of information, a subsite in the COMPANY's SharePoint server was created. In this subsite, based on Microsoft SharePoint technology, were created 4 lists, referring to the records of entrances and exits of vehicles in the facilities, the movements of the all the keys, daily reports and entrances and exits of

workers between the two main sections (which have different lobbies). The last list did not exist at all in the company and was extremely important to have real data concerning the amount of people within the factory, in case of an emergency.

2.3.3. Documentation Control

When it comes to documentation control, since the COMPANY hires several service providers' companies, the first stage of developing the new file consisted in collecting data from all the hired companies at the time. Knowing which companies are present in the facilities and the task they usually perform, three levels of risk were created: low, medium and high. The low risk level includes all service providers which tasks do not interfere directly with production and are not performed within the production area, such as vending machine replenishment personnel, informatics' technicians or laboratory personnel. As medium level were considered all service providers which perform tasks in the production line, only if the tasks do not have increased risk. Finally, high risk service providers are the one which perform increased risk tasks. These last workers are obliged to present, besides the legal documentation, a safety plan and procedure for the task.

The file was developed using Microsoft Excel software. In this file all the required information is structured and easily analyzed and verified. There are two main sheets in the file, concerning external companies' documentation, on one hand, and external workers' documentation, on the other hand. All the legal documentation, such as insurances, personal protective equipment possession and medical files were contemplated in the file.

Using a Visual Basics for Applications (VBA) code, which is the Microsoft Excel coding language, to analyze the information concerning workers' documentation, the developed file determines which service providers are approved (the ones that comply with all the legal requirements) and creates a list of approved workers, which is used in the lobby by the security personnel to identify which workers are allowed to enter the facilities. This list is shared in the COMPANY's Microsoft SharePoint.

2.3.4. Work Permit System

In the normal operation of an industrial plant, there are several maintenance, improvement and process development interventions. To ensure the safety of their execution, it is necessary to perform a risk assessment to the job itself. This is easily done using a work permit system, which allows a communication between the worker and the area manager concerning the kind of task to be performed, the risks and the prevention measures to be taken into account for a safe execution. This procedure ensures that everyone who is involved in the task knows the risks and the prevention measures associated to it.

It was defined that, after the Maintenance Department received a request in their server and produced the work order, the worker who would perform the task is required to meet with the area manager/supervisor and discuss the risks of the tasks and the prevention measures. As soon as the area manager agrees that all the safety conditions are ensured and right before the beginning of the task, the work permit is issued (process described in Figure 1), being valid until the end of that day's working shift. This work permit has to be recorded in the COMPANY's server.

The worker, or one of them if there is a team, receives the work permit after it was signed by him and the area manager and carries it during the entire task, from the beginning until the conclusion.

At the end of the working shift, the worker returns the work permit to the area manager, if the task was not completed. In the following working day, the work permit is returned to the worker, after the initial checkup of the safe working conditions.

When the work is concluded, the area manager needs to check the correct conclusion of the work, *i.e.*, if the work was done properly and if the area was cleaned, including the residues management.

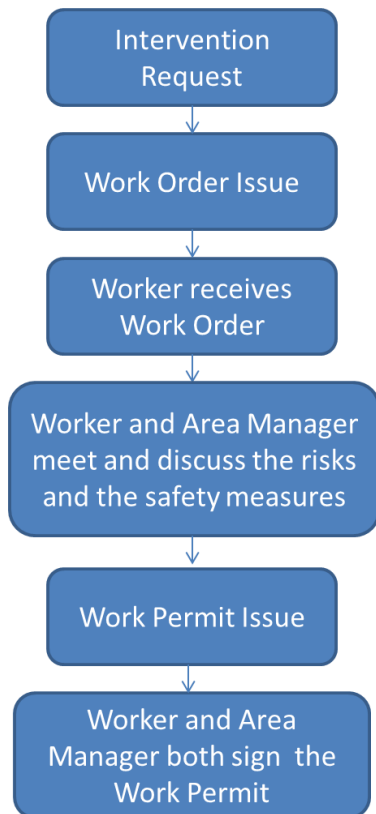


Figure 1 - Work Permit Issue Process

After defining the work permit system, a formal work permit was created. The COMPANY chose to design a new formal work permit instead of using one of the available in the literature, since it was extremely important that the work permit reflected the COMPANY's industrial reality. However, this available work permits were studied and analyzed in order to come up with the best solution for the COMPANY.

The new work permit included a part from the trivial header with the type and location of the job to be performed, a risk analysis, including some increased risk tasks, a safety validation (including the isolation of the area, the tag and lock procedure, the previous cleaning and the residues management), a signature area and an attachment with the verification of specific preventive measures for different increased risk tasks (such as hot jobs, confined spaces, piping or working at height).

The entire work permit was based in checklists, to ensure the simplicity and quickness of the procedure.

3. Results and Discussion - Phases Four and Five: Check and Act

This chapter will be divided into two sections: results of implemented solutions and implementation plan and expected results of non-implemented solutions.

3.1. Implemented Solutions

The documentation control file and the lobby records were already implemented and it was easily seen how they improved these daily tasks.

Concerning the documentation control file, the COMPANY's safety technician tested the first version of the control file, as a pilot test (check phase). It was verified that the file needed some alterations: the control of the medical file did not include an automatic verification of its expiration date, nor the initial training date was included. Therefore, these changes were done in the file and after some minor adjustments (act phase), it was verified that the goals set for this solution were met. In fact, the approval of service providers was easier and quicker, especially when it came to workers who already had done some kind of work in the facilities. Including the automatic verification of expiration dates for insurances and medical file allowed a simpler update of the documentation and a better control of these legal documents. Nevertheless, the biggest impact in the COMPANY was the automatic list of approved service providers, as it made the control process extremely easier. There is no need to check all the data again, since the approved workers' name are in this list and the security does not need to contact the Safety Department to ensure that the work is apt to enter the facilities.

Looking at these results, it is clear the importance of data management, even in industrial safety. The verification of insurances' expiration date ensures the compliance with the current legislation and it is an easier way to verify this compliance. In short, this method allowed a great reduction of wasted time and resources, as well as a better control of all the stated legal aspects

The lobby records were also implemented during this work. Since the records were usually done in paper, the first result to be observed is the clear decrease in the use of paper, improving the COMPANY's

environmental awareness, as well as the decrease in bureaucracy. After receiving feedback from the security, it was necessary to implement some changes in the records: initially, only one entrance and exist was allowed for every vehicle, per day, which did not correspond to the daily behavior in the COMPANY; some keys appeared as separate keys in the file, when they were actually a set; the daily occurrence record file did not include who was the security guard in duty. After implementing these changes, it was easily seen how these lists made the daily record tasks much simpler and organized. The biggest impact, however, was the internal movements between the two main sections of the factory, which was not a routine in the COMPANY. This is extremely important when it comes to safety, as it became possible to determine precisely how many people there are in each facility. This is even more important in case of an emergency, as well as the precise knowledge of the vehicles inside the facilities.

3.2. Solutions Awaiting to be Implemented

An implementation plan was studied for both the improvement suggestions: safety regulation for service providers and work permit systems.

Concerning the first one, the safety regulation itself should be sent to a few selected service providers' companies (pilot test) during the months of September to November, 2017 in order to receive feedback from these companies until the end of the year. This way, the identified improvements could be implemented in the beginning of 2018 and, by the end of January, the regulation would be implemented to all the service providers' companies.

It is predictable that the implementation of the safety regulation for service providers is going to improve the safety conditions in the tasks, since the external workers are more aware of the rules they have to oblige. This way, it is expected that the Safety-Based Behavior culture is going to increase, leading to a major improvement in the safety working conditions.

When it comes to the circulation flyers, it is predictable that the road safety is going to increase. Since the routes were designed to

decrease or even eliminate the resource to dangerous maneuvers, implementing these flyers will lead to a bigger safety for the drivers, the workers and the facilities themselves. It is also expected an increase of the compliance with rules and use of personal protective equipment, since the awareness for the dangers and the safety rules are explained in the flyers. This is an easily implemented point, so it should happen as soon as possible.

Finally, concerning the work permit system, after analyzing different implementation routes, it was decided by the COMPANY to apply a pilot test, since the workers showed reluctance to accept this new working procedure. A pilot test allows to study the impact of the procedure, with a very small chance of failure and to confirm the expected results. After an initial meeting to define the trimmings of the project, the implementation would start with 2 weeks of on job training, to ensure that all shifts would receive the same amount of training. This training would be done in two sessions: a first one, explaining the system and how it works, and a second one, reviewing the explanation given before and running the pilot test. The pilot test would be performed on an increased risk task, to ensure the maximal complexity of the system. At the end of the pilot test, an anonymous survey will be distributed to the workers to identify corrective measures.

It is expected that, after running the pilot test and implementing the corrective measures, the trust of the workers in the system will increase, as well as their acceptance. On one hand, it is mandatory to have communication between the maintenance department and all the production areas, eliminating the lack of control and of verbal authorization. On the other hand, the safe working condition are discussed and verified by, at least, two people, and the work is prepared, therefore, reducing the risk of an accident. It is also predictable an increase of the tidiness and cleaning of the working area, which was also a problem in the COMPANY. Finally, it is expected a rise in the workers awareness concerning industrial safety, increasing the overall safety of the facilities.

4. Conclusions

The chemical industry faces several challenges and Industrial Safety and Hygiene is one of the biggest challenges to be faced. At the COMPANY, several points needing improvement were identified and this work consists in the preparation of a set of proposals and the plan to implement of some of them.

When it comes to service providers, the pre-qualification and approval of external workers was changed, through the creation of an automatic documentation control file. The criterion used in this file obliges to the Law Decree 102/2009, September 10th, and allows a simplified process to manage this information. In this point, the prioritization of the service providers' risk allowed a better judgement of the needed documentation.

The creation of a safety regulation allowed a better systematization of the safety rules, as well as the execution rules. This regulation also allows a better communication between the COMPANY and the hired service providers, as well as a greater awareness for the importance of safety.

The digitalization of the lobby records showed how critical it is to have a systematic approach when it comes to managing data. In terms of safety, it allows a more precise data concerning the amount of people and vehicles within both sections of the facilities.

The circulation flyers lead to a greater road safety within the facilities, eliminating the need for dangerous and unpredicted maneuvers,

Finally, the work permit system allows a meaningful rise in the safety conditions of maintenance operations in the COMPANY, since it compels the communication between workers and area managers, clearly stating the risks and preventive measures of each task.

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