



## Preliminary ergonomic analysis of a small company manufacturing nautical cables

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### Summary

Although they are responsible for 27% of Brazilian GDP and 52% of formal jobs in the country, micro-enterprises are not the basis for defining best Occupational Health and Safety (OHS) practices. Furthermore, the guidelines of OHS legislation are aimed mainly at the largest business conglomerates. Thus, this work aimed to carry out a primary diagnosis of the ergonomic situation of a micro manufacturing company in the nautical sector, using the DeParis method to identify critical work situations. 3 operators and 1 manager were interviewed. For each rubric analyzed and discussed, the resulting facial expressions were defined by consensus. In this analysis, it was possible to indicate situations of necessary actions and classify them as satisfactory, unsatisfactory or subject to danger. Finally, the 5W1H tool was used to propose planning improvement actions. As a result, six items were critical to the work context: workplaces, accident risks, repetitive work, heavy handling/lifting, noise and work relationships between workers. The main problems identified were working postures, dangers of equipment accidents, handling heavy loads and dispersion due to monotonous and repetitive work. It was concluded that the application of the method was fundamental for understanding the main issues related to the items, and for the participation of operators. It was possible to suggest more assertive and viable improvements for the company.

**Keywords:** AEP; Scratches; Participatory ergonomics; From Paris.

## 1. Introduction

A microenterprise is a company with annual revenue of up to 360 thousand reais, employing up to 9 people in the commerce and services sector or up to 19 people in the industrial sector (PORTAL DA INDÚSTRIA, 2019). The opening of this type of company in Brazil has increased over the years, and they are responsible for 27% of Brazilian GDP and 52% of formal jobs (SEBRAE, 2021). On the other hand, this type of company does not have widespread Occupational Health and Safety (OHS) fundamentals and practices (LEGG et al., 2015), presenting a challenge to its processes. The best SSO practices are still based on the characteristics of large companies (LEGG et al., 2015), mainly to comply with legislation that regulates these largest business conglomerates as a priority (ZENG et al., 2014).

As a result, ergonomic and security interventions in OHS in micro and small businesses (MSEs) are strongly shaped by traditional and functional experiences and practices in larger organizations, but are not always adequate or adjusted to the reality of small businesses. This situation, combined with the recurring scarcity of resources for investment (in human, financial or time resources), means that OH&S interventions are not as present in MSEs (LEGG et al., 2015). For Champoux and Brun (2001), the lack of education and training in smaller companies results in harm to health and safety actions, resulting in non-systematic approaches and the use of control measures that are not very elaborate in implementing OH&S practices.

In Brazil, companies' SSO is guided by the Federal Government's Regulatory Standards (NR). These standards have the weight of law and, if companies do not comply with their guidelines, fines and punishments may occur. The application of these NRs in the country is widespread in large companies, mainly due to the activity of regulatory bodies and efficient occupational safety policies (VILAS BOAS; GASQUES, 2018). NR-1 determines that it is an obligation of all employers with workers under the CLT regime - Consolidation of Labor Laws (except Individual Microentrepreneurs, microenterprises and small businesses without occupational exposure to physical, chemical and biological agents, in accordance with the NR 9) develop a Risk Management Program (PGR) with the aim of operationalizing Occupational Risk Management (ORM), defining and promoting actions that provide healthy and safe working conditions and environments (BRASIL, 2022). In this sense, and together with the lack of knowledge on the part of employers and employees, micro and small companies end up not

evaluating their operations from the point of view of occupational risks (BRASIL, 2010). This context ends up creating a pretext for a series of issues that can hinder the development of companies, such as: accidents at work, increased occupational risks, low quality of life at work, development of WMSDs (Work-Related Musculoskeletal Disorders), among others.

An ergonomic methodology widely used in risk management is SOBANE (Screening, Observation, Analysis, Expertise, or preliminary analysis, observation, analysis and expertise). This method is structured to analyze working conditions in companies, aiming to prevent risks quickly, efficiently and at low cost (DA SILVA; AMARAL, 2018). The Participatory Risk Diagnosis (DeParis) is a qualitative method for risk analysis (MALCHAIRE, 2003), which makes up the first level of the preliminary diagnosis of the SOBANE strategy, which consists of a questionnaire with 18 headings related to different aspects of the work (DA SILVA; AMARAL, 2018). When applying the method, the desired situation is described, and by a figurative system of colors and facial expressions that indicates the degree of urgency of intervention in the issue to be addressed (SCHREINER et al., 2008).

The method involves the active participation of workers and managers in identifying aspects linked to safety, health and well-being, consequently impacting productivity (MALCHAIRE, 2003). Therefore, a participatory method that encourages workers to discuss and determine which practices are most applicable to the company's routine in terms of health, safety and ergonomics. Therefore, the objective of this research was to carry out a primary diagnosis of the ergonomic situation of a micro manufacturing company in the nautical sector, mapping the existing risks of the current operation and proposing improvement solutions.

## **2. Method**

The company that was the subject of the study operates in the field of nautical cables and, during the research, had been operating for approximately one year. The sector in question was in the initial phase of development in Brazil, with the majority of products sold at the time being imported. The main customers were stores that sold equipment for sailing and yachting.

Producing a wide variety of types of nautical cables on demand, the company was located in a large area and operated with 12 machines, each of which constituted a workstation. The work was divided into three shifts with rotation between the 6 operators who were formally

hired, under the CLT regime. It was not necessary for all items produced to pass through all workstations; this was determined by the specification of the item demanded. Ear protectors and gloves were provided as PPE. The use of closed shoes was considered mandatory, although a standard model was not available.

## 2.1. Application of the DeParis Method

The application of the DeParis Method began with a visit to the company, in which it was possible to better understand the processing flow, understand the physical space, equipment and furniture available, observe and catalog the first foci requiring analysis and interview some of the participants of the process. During the visit, the 18 headings of the method were discussed during a guided interview with three of the operators and the manager of the analyzed processes.

With the intention of complementing the application of the tool, questions were used to assist in the discussion of each heading, as exemplified in Chart 1. The questions were discussed and answered by the working group formed, with the assistance of the researchers of this work on agendas of approximately 20 minutes each.

**Table 1** – Fragment of questions to encourage and complement the discussion of the headings

<b>HEADING: Workplaces</b>
- Is the work carried out in a sitting position on a comfortable and stable chair, with sufficient space for the legs under the work surface or is it work standing up without any obstacles to movement? - Are the work surfaces at an appropriate height, arranged in a way that allows the shoulders to be relaxed, the arms along the body and the feet resting freely on the ground or on a comfortable footrest? - Does the work require kneeling, squatting, trunk twisting, raised arms positions?
<b>HEADING: Accident risks</b>
- Ask about each of the following risks and their severity: shock, falling people, falling objects, crushing, fracture, cuts, stings, abrasion, burn, electricity, projection, fire, explosion, crashes, among others; - Are PPE such as gloves, helmets and glasses used?
<b>HEADING: Repetitive work</b>
- Does the work require continuous repetition in the same positions and efforts? - If repetitive, was the work organized taking into account optimal anthropometric positions?; - What is the cycle time and the number of repetitions of the movement throughout this cycle?;
<b>HEADING: Handling/lifting weight</b>
- Are the loads light or heavy?; - Is the trunk twisted when handling these loads?; - Is mechanical assistance necessary to handle the load?; - Are the distances and heights for picking up and depositing loads comfortable?; - Are the loads easy and comfortable to hold? - What is the height at which the loads are removed and placed in relation to the waist reference point?; - Are gloves used as PPE?
<b>HEADING: Noise</b>
Is it possible to talk normally at a distance of 1 meter?; - If there is noise, what is the origin and condition of the machines or installations from which this noise comes?; - Is there a noise control mechanism?;
<b>HEADING: Labor relations between workers</b>
- Is there organization and division of labor?; - Are breaks, rotations, breaks and substitutions made?; - Are there workers who are isolated or excluded from the group?; - What is the group's autonomy in managing tasks?; - Do workers know and respect hierarchical relationships, responsibilities and delegations?

**Source: Adapted from MALCHAIRE, 2003.**

The working group took place in the form of a meeting, where the issues discussed were recorded by the researchers in order to formulate a table of responses. In this table, the status of each item was determined by indicating facial expressions and color: green color and positive facial expression meant a satisfactory situation; yellow color and neutral facial expression meant an average situation that could be improved; and red color and negative facial expression meant an unsatisfactory situation, subject to danger and in need of improvement. For each point discussed in each rubric, it was agreed that the expressions and colors that the group considered appropriate to the situation would be determined, so that at the end of the agenda a general expression would be chosen to define the rubric based on consensus among the participants, taking into account the discussions previously held.

Given the information collected and analysis using the DeParis method, proposals for improvements were made. The 5W1H tool was used as planning for the application of these improvements, and thus a summary table of action plans for the main improvements indicated was constructed. Such a tool, in addition to prioritizing the most critical situations, would also provide a greater insight into how actions should be carried out.

### **3. Results**

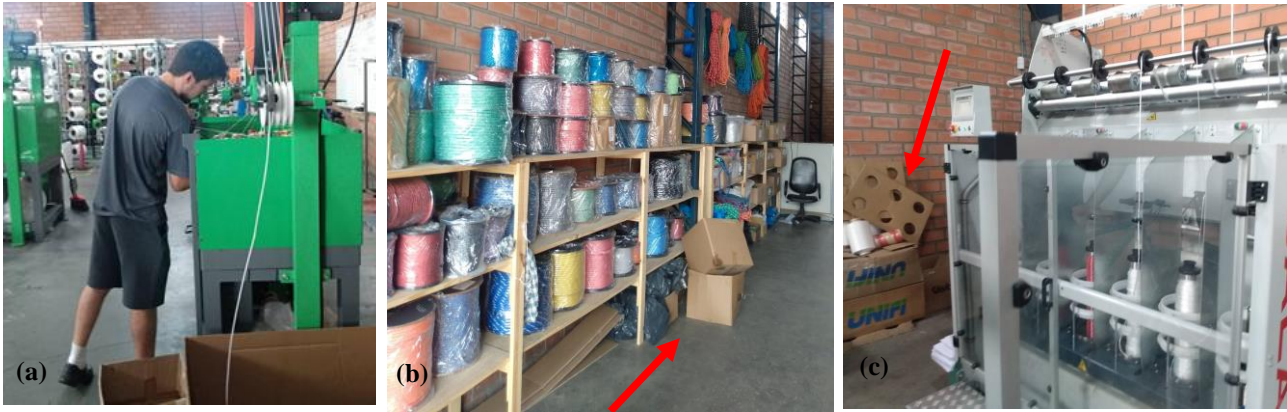
In this study, the work environment was fully evaluated considering all workstations due to there being no physical delimitation and no exclusive collaborators in each post. During the discussion, there was active participation from everyone present. The meeting took place smoothly and the time stipulated for each agenda was considered adequate.

Within the delimited scope of the study, it was decided to present and deeply analyze the results of only those items that were considered most relevant during the application of the DeParis method and that, consequently, were identified as those that required the most attention in the factory or that represented a greater potential for detailed study. The headings selected for presenting the results were as follows: 'Workplaces', 'Accident risks', 'Repetitive work', 'Weight handling/lifting', 'Noise' and 'Relations of work between workers'.

Under the heading 'Workplaces', the most critical issue raised was related to work postures – mostly performed standing, sometimes requiring squatting and trunk twisting (Figure 1a). Two intermediate priority issues were mentioned, the lack of delineation of areas for each

operator during operation (Figure 1) and inefficient waste management (Figure 1b and Figure 1c). Furthermore, the location was characterized by employees as being easily accessible and in good condition so that the activities could be carried out well.

**Figure 1** – (a) Trunk twist and absence of area delimitation; (b) and (c) Waste packaging



**Source: Authors, 2023.**

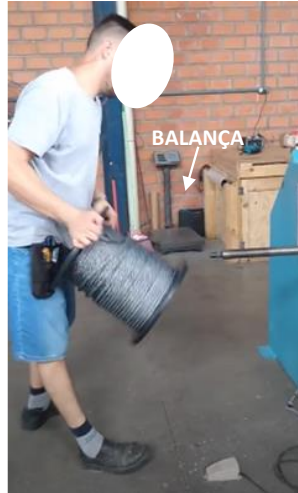
The heading 'Accident risks' had the greatest number of issues that needed urgent changes, with the maximum level of criticality: (i) lack of protective devices to prevent accidents related to the operating speed of the machines (which operated within reach of members operators); (ii) drying oven developed by the operators themselves, without specific characteristics and functions; and (iii) the cable cutting stage, carried out without the appropriate equipment to prevent accidents. The availability of PPE was characterized as an intermediate level of criticality, with some being made available by the company, but without standardization, supervision of use or awareness policy. Finally, the machines were characterized as new, in good condition, and with light and sound signals during operation.

The heading 'Repetitive work' brought notes of critical priority due to it being characterized as monotonous and repetitive, generating dispersion. The postural issue generated discomfort, with flexion of limbs and head. With an intermediate level of urgency, it was found that workers ended up getting involved in each other's activities without planning and control. Furthermore, all operators knew all the activities and were able to work in any workstation.

Regarding 'Weight handling/lifting', only the process of weighing and packaging the spools was characterized as extremely urgent. At this stage, operators handled products weighing between 0.5 kg and 22 kg, involving positioning them at waist and floor level (Figure 2). The same situation was reported during the raw material allocation stage, but because it involved less effort (masses from 0.5 kg to 12 kg) it was characterized as intermediate priority.

Another point classified as intermediate was the transport of cables between operating stations, carried out by dragging boxes using arms or legs.

**Figure 2** – Lifting the spool to move it to the scale



**Source:** Authors, 2023.

Regarding the heading ‘Noise’, the topics were classified at the intermediate level of urgency. During the meeting, it was informed that a preliminary study had been carried out by a professional audiometrist to evaluate the noise conditions during the operation. The noise was assessed as intense, but acceptable, within established standards, considering the mandatory use of ear protectors to prevent long-term damage. Despite the determination and availability of hearing protectors for all employees, there was no adherence to their use. It was also observed that both the noise and the ear protectors interfered with oral communication between operators and, consequently, the operation.

The heading ‘Work relations between workers’ presented a point with intermediate priority: the exchange of jobs between workers in idle moments, without the manager’s knowledge. Furthermore, it was evident that employees were cooperative, teaching and learning together in harmony. The operation manager was respected and his instructions were followed and complemented. Table 2 summarizes the main results of the 6 items presented, together with the criticality classification determined and the improvement proposals raised.

Using the DeParis tool, it became clear that the activities were carried out empirically, with no alignment with the prescribed activity – which was still structured in a rudimentary way in the company. This fact could be due to the excellent working relationship between operators

who were constantly helping each other and seeking to make activities more fluid due to their repetitiveness.

Employees appreciated the workplace, but some points related to waste management and operational layout were cited as aspects to improve. There were also reports regarding inadequate postures performed during operations. The possibility of a postural and anthropometric study of workstations by both operators and managers was viewed positively.

Both the manager and the operators recognized the risk of accidents, especially during operation with the machines and in their surroundings. The manager stated that due to the specificity of the machinery, at the time of acquisition, there were no other safer models. It was mentioned that the manufacturer could be asked about any updates to parts (such as a security camera) that would protect operators. The need for a reformulation of the company's PPE policy was also raised, combined with a policy and awareness about its use.

All participants agreed that the tasks were repetitive, but they considered it positive that they could change operating positions with their colleagues. The production manager pointed out that this change was not recommended due to the specifications and exclusive responsibilities of each position, but that he was not opposed to the internal organization of employees as long as it did not interfere with productivity.

At specific points in the process, issues relating to cargo handling were identified. Operators most strongly cited the packaging stage, which involves bending the trunk and lifting loads of up to 22 kg. Other steps mentioned were replacement of raw materials and transport between stations.

Another important issue was related to the heading 'Noise'. The manager informed that there was a noise assessment carried out by an external professional hired shortly before this study. The assessment classified the noise emitted during production as acceptable, considering the mandatory use of hearing protection equipment. Even so, the operators indicated the difficulty of communicating with other operators and with the manager when using the protector, pointing out that, for them, this fact justified not using PPE on a daily basis.

Working relationships between workers were described in a positive way, with mutual help between operators and respect and contributions towards the manager. The only issue that was indicated for possible intervention was related to the workflow at stations, resulting in idleness and task confusion among operators. The solution proposals based on the diagnosis



obtained with the application of the DeParis method were listed using the 5W1H tool, as shown in Table 3.

**Table 2 – Main results of the practical application of the DeParis method**

Heading	Answers	Improvement proposals	Classification		
The workplaces	The work is done standing up and sometimes squats and torso twists are performed.	Carry out a postural and anthropometric study. General study of the workstation to check the layout of machines and tools.			☹️
	There is space to carry out all the necessary movements, but without delineating the areas of each operator.	Well-marked physical delimitation (with positioning stickers) at workstations.		😊	
	The location is easily accessible and in good condition so that the activities can be carried out well.		😊		
	There is no waste management, resulting in accumulation and lack of definition of the location for storing waste.	Implement Solid Waste Management Plan.		😊	
Accident risks	Ear protectors and gloves are available as PPE. The use of closed shoes is mandatory, but they are not available.	Formulate a kit with all necessary PPE and encourage correct use through internal awareness programs.		😊	
	The machines are new and have sound and light signals.		😊		
	The speed of the machines is high and there is no exclusive protection.	Look for safety devices that prevent contact with the machine in operation. Set minimum distance from the machine in operation.			☹️
	The drying oven was developed by the operators themselves and is not specific to its intended use.	Acquisition of a dryer.			☹️
	Risk of accident during the cable cutting stage, carried out using a knife.	Provide for the use of a tool without an exposed blade (cutting pliers). Create a specific workstation for using the thermal cutting machine.			☹️
Repetitive	Monotonous and repetitive work, there is dispersion.	Determine rotation between jobs. Create schedule for breaks during			☹️

work		shifts.			
	Workers engage in each other's activities during longer cycle times	Plan exchanges between jobs during longer cycle times.		☺	
	There is flexion of limbs and head.	Carry out postural and anthropometric studies.			☹
	All operators know and are able to work in any workstation.	Schedule a schedule with rotation of operational posts.	☺		
The handling/ weightlifting	The reels are manually loaded from one station to another (approximate distance of 2m). Masses vary from 0.5 kg to 22 kg.	Unify activities in just one workstation. It is proposed that the scale and the place for packaging be placed on the same level as the machine that forms the spools.			☹
	The allocation of raw materials to the distributing machine involves manual transport from the stock sector (approximate distance of 2m). Masses vary from 0.5 kg to 12 kg.			☺	
	Boxes with ready-made ropes are moved by dragging without standardization.	A wheelbarrow can be used to move the ropes between posts.		☺	
The noise	Ear protectors are available to all employees, but there is no compliance with their use.	Implement a policy to raise awareness of the use of PPE. Elect one employee per month to be the PPE inspector.		☺	
	Noise disrupts oral communication between operators.	Participation in non-verbal language courses. Implement more light signals on machines.		☺	
Labor relations between workers	Employees help each other, teach and learn together. There is harmony between the team.		☺		
	Excessive autonomy in changing jobs.	Avoid interfering in the activity of another post while it is being carried out, except when actually requested and possible.		☺	
	The operation manager is respected and his instructions are		☺		

	followed. Employees question and complement the manager, helping to optimize activities.				
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**Source: Authors, 2023.**

**Table 3** – Breakdown of improvement proposals in 5W1H

<b>What will be done?</b>	<b>Who will do it?</b>	<b>When will it be done?</b>	<b>Why will it be done?</b>	<b>Where will it be done?</b>	<b>How will it be done?</b>
Postural and anthropometric study	Third party	Second half of 2023	To analyze and check postures and workstations, also optimizing the arrangement of machines and tools, in addition to physically delimiting workstations.	In the company itself	Ergonomic methods will be applied to define the optimal configuration of the company's layout and workstations.
Solid Waste Management Plan	Outsourced environmental management company	First half of 2023	To regularize waste management by providing an exact definition of waste management conduct in the routine operation.	In the company itself	A study of the site will be carried out, with analysis of the space for waste allocation. The waste will be classified and it will be studied whether there is a need for special disposal.
PPE kit	Outsourced company + lead SSO collaborator	Immediately	To ensure the use of PPE.	In the company itself	PPE will be purchased as recommended. The kits will be personalized, containing the name and instructions for use. They will be renewed periodically as instructed.
Acquisition of a drying machine	Manager	Immediately	To regularize the drying process in a machine designed for this function.	In specific supplier	Contact will be made with companies that supply drying machines. The machine with the best cost-benefit will be purchased.

Research into safety devices that avoid direct contact with machines in operation	Manager	Immediately	So that a survey can be made of the existence of these devices on the market, in a safe way, and that they can be used in machines.	Internet and telephone contact	Contact will be made with the companies that supply the machines to ask if there is a device that meets the demand.
Creation of a new cutting workstation using the thermal cutting tool	Workers	Immediately	To enable the use of a tool that is already available, but not used on a daily basis because it is not prepared in an accessible place.	In the company itself	The thermal cutting machine will be allocated next to one of the machines that generates the greatest demand and will be placed in conditions for immediate use.
Acquisition of cable cutting pliers to replace the stylet in the cutting stage	Manager	Immediately	To replace the cutting tool with an exposed blade with a safer one.	In specific supplier	Specialized cutting pliers that do not damage cables and do not pose an accident risk will be purchased from specialized tool stores.
Changing the location of the scale	Workers	Immediately	So that the spools can be weighed without having to travel.	In the company itself	The scale will be relocated. This movement will be manual, as it is a light scale.
Election of employee responsible for SSO	Manager	Monthly	So that a culture of occupational safety is created.	In the company itself	A meeting will be held on the first business day of each month. Employees, with the manager's encouragement, must initiate an open vote to define the OH&S leader.

Source: Adapted from MALCHAIRE, 2003.

#### 4. Conclusions

The proposed objective of carrying out a primary diagnosis of the ergonomic situation of a micro manufacturing company in the nautical sector was achieved. The application of the DeParis method contributed to the identification of critical work situations, enabling the mapping of existing risks in the operation and the proposition of immediate improvements to increase comfort, safety and productivity. Both the results presented, mainly with the action plan for implementing the proposed improvements, and the discussion itself and the dynamics of application of the methodology were considered relevant and of high contributory potential by the company representatives, motivating other actions and subsequent internal discussions.

Another concern present during the study was the use of methods aimed mainly at large companies to be applied to the context of a micro-enterprise. However, with the observation of small, easily identifiable adaptations during application, it was considered that all the tools used were adequate to provide the action in a methodological manner, even in the unstable environment of small businesses. They were also fundamental in guiding accessible intervention proposals with potential significant results. Even so, the possibility of creating a standard protocol for the implementation of preliminary ergonomic analysis aimed at MSEs, which would take into account their distinct characteristics during development, rather than treating them as exceptions, was seen as interesting by the development team. work, and remains as a suggestion for future work.

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