Challenges and Risks to Workers' Health and Safety in the Dismantling of Flexible Pipelines in Brazil

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Abstract. The dismantling of flexible pipelines, within the context of decommissioning subsea oil and gas production systems, involves technical and operational activities that reflect the complexity of risk analysis to the health and safety of workers throughout all stages of the process. This study aimed to analyze the health and safety risks for workers involved in the dismantling activities of flexible pipelines. The methodology adopted combined semi-structured interviews and direct observations to collect relevant data on working conditions at a recycling company. Information was gathered on the dynamics of operations, the number of workers involved, potential risks, and the duration of activities, based on the principles of Ergonomic Work Analysis. The results emphasize the need for a more robust approach, adapted to the Brazilian context, considering the real conditions of operations and the complexity of the labor activities involved, from planning to the dismantling of flexible pipelines. The study highlighted the need for monitoring actual work to map out risks, as well as strategies for communication between stakeholders throughout the entire production chain, increasing transparency and traceability of recycled materials. The use of software such as CAPTIV in future studies could provide critical insights into ergonomic factors, optimizing risk mapping and promoting improvements in the health and safety conditions of workers.

Keywords: Dismantling, Risk, Health and Safety.

1. Introduction

Oil is the most important commodity in Brazil’s energy matrix (Ferreira et al., 2020). Offshore oil and gas fields, however, have a finite production lifespan – and once an installation has ceased to produce it must be decommissioned (Ferreira et al., 2020). In Brazil, 2.800 fixed platforms and 160 floating platforms are planned to be deactivated by 2030 (ANP, FGV, 2021), and their respective subsea installations, which are rather

(Godoi & Matai, 2021), shall be decommissioned with them. The decommissioning of subsea installations and equipment presents logistical challenges (Martins et al., 2020) that may be exacerbated in deep waters (Martins et al., 2020). Additionally, these structures present different compositions that require a variety of operations and equipment for decommissioning, with total or partial removal being accomplished through different techniques that might be available depending on the characteristics of the equipment and the environment (Martins et al., 2020).

The decommissioning of flexible pipelines in subsea oil and gas production systems ranges from the recovery of materials on the ocean floor to waste management after dismantling (Souza, 2022). In Brazil waste management is guided by The Brazilian National Solid Waste Policy (PNRS – Política Nacional de Resíduos Sólidos). This policy stipulates that in waste management the priority should be non-generation, reduction, reutilization, recycling, solid waste treatment and environmentally adequate disposal. In literature, however, the recycling of flexible pipelines remains as a relatively unexplored area, especially regarding aspects related to worker health and safety. This gap in literature is accompanied by a lack of more in-depth attention in legislative, regulatory aspects, and the development of more robust safety plans for the workers involved (Souza, 2022), despite the relevance of the topic. The need for such in-depth studies and regulations becomes even more evident when considering the complexity of operations and the need to safeguard the physical integrity and health of professionals at all stages of the process (Wifa et al., 2023).

In this context, this study aims to analyze the health and safety risks to the workers involved in the dismantling of flexible pipelines in the context of decommissioning activities through a case study conducted in a dismantling company in the state of Rio de Janeiro, in Brazil. The paper is structured as follows: Section 1 presents the introduction, and the concept of ergonomic studies adopted in the conduction of this work. Section 2 establishes the procedures adopted for data collection and the motivation behind the choice of a case study as the method to investigate this topic. Sections 3 and 4 present the results and discussion, respectively. Section 5 provides the concluding remarks, and Section 6 includes the acknowledgments.

1.1 Activity Ergonomics

The nature, adverse conditions, and complexity that define the dismantling of flexible pipelines characterize this activity as one where the application of Activity Ergonomics concepts is highly relevant. The activities require physical effort, exposing workers to weather conditions and risks associated with handling sharp and heavy equipment. In this context, the concept of 'working conditions' allows for the identification and control of variables that affect performance and safety, encompassing both physical and psychological aspects (Leplat and Cuny, 1977).

The approach based on the 'determinants' of work expands the analysis beyond the task, also considering environmental and organizational factors that may impact the operators' performance (Guérin et al., 2001; St-Vincent et al., 2011). On the other hand, the perspective of Dejours et al. (2008) emphasizes the importance of understanding the workers' subjective experience when facing the real challenges inherent to the activity, such as pressures, unforeseen events, and the constant need to adapt between prescribed and actual work. The analysis of real activity, focusing on the worker's experience, contributes to identifying coping strategies and proposing effective interventions.

The application of the principles of Work Ergonomic Analysis (AET) provides a detailed description of the activities and a more precise identification of the risks inherent in each stage, covering not only the physical aspects but also the organizational, social, and environmental ones (Wisner, 1987; Guérin et al., 2001). This dynamic method, based on the active participation of workers in identifying the difficulties encountered during task execution, is important for highlighting discrepancies between prescribed and actual work, allowing for the detection of risk situations that may go unnoticed in conventional analyses (Dejours, 2008). Thus, it enables the development of solutions that minimize physical efforts, improve the conditions of the productive environment, and promote safe work. This approach not only contributes to the health and safety of workers but also to the overall efficiency of the process, reducing operational failures and increasing the reliability of dismantling operations.

1.2 Economy of functionality and cooperation

Conducting an analysis of the labor activities and the ecosystem in fundamental to promote effective changes in pipeline dismantling. Innovation and the search for more efficient and sustainable solutions outlined in the EFC (Functionality and Cooperation Economy) advocate for a systemic and integrated approach (Lima et al. 2022), which may reflect on health and safety aspects, transcending the physical issues of workers and considering social, psychological, and organizational factors with the aim of promoting a safer work environment.

By defending collaboration and cooperation among various agents, EFC promotes the sharing of information between companies within the ecosystem through agreements aimed at optimizing operational strategies, the efficient use of resources, and the monetary value associated with the business. This interaction allows participants to enhance their understanding of mutual commitment, which is essential for the consolidation of a new ideal (Tertre et al., 2019).

2. Methods

This paper addresses the dismantling of flexible pipelines used in the oil and gas industry, a specific process within the context of recycling activities. The exclusive nature of this process, combined with the gap identified in the literature regarding the study of onshore stages of decommissioning projects (Santos et al., 2024), motivated the development of this work in the form of a case study (Yin, 2005). The case study is a method of observing social reality that employs various research techniques in social investigations, such as interviews, participant observation, document reviews, and life story collection (Godoy, 2005). It is a research strategy that allows for the exploration of a phenomenon within its real context, using multiple sources of evidence to enhance the robustness of results (Yin, 2005).

Data collection was carried out through semi-structured interviews combined with direct observations. This combination aimed to include two distinct sources of evidence to ensure the robustness of the case study data. The interviews allowed for gathering targeted and focused information on the study topics, while direct observations enabled the capture of real-time event data, essential for identifying health and safety risks for workers. Research participants were selected based on the criterion of being actively working at the workstations visited on the day of data collection. Through the interviews, it was possible to obtain information about work operations, daily variabilities, a detailed account of each executed step, and the challenges faced by workers. At the end of each interview, a summary of the collected information was prepared and later presented to the participants for validation, ensuring the accuracy of the obtained descriptions. The data collected were recorded in field diaries by the authors, including descriptions of the services performed by the group, the number of workers involved, potential risks, the average duration of operations, and the sequence of activities. These data were used to construct a model of the observed process, employing the BPMN (Business Process Model and Notation) method. The model consists of an abstract representation of the observed reality, depicted through a flowchart, with the primary goal of facilitating the understanding of the process (Baldam et al., 2014). The collected data was also used to generate a detailed description of the activities, enabling an understanding of the work based on the concepts of Work Ergonomic Analysis (Wisner, 1987; Guérin et al., 2001).

3. Results

On November 6, 2024, a visit was conducted lasting three and a half hours to the recycling company located in Rio de Janeiro (Brazil), with the aim of observing the flexible pipeline dismantling activities. On the same occasion, two interviews were held with managerial-level employees of the company, lasting approximately one hour each. The company is part of the decommissioning chain for subsea equipment through the purchase of decommissioned pipelines auctioned by operators responsible for oil and gas production. After purchasing the flexible pipelines, the recycling company dismantles the material, sends the polymers to be pelletized, receives the pelletized polymers, and sells them to companies that process them for new applications, generating the Final Disposal Certificate. The complete flow of decommissioned pipelines can be observed in Figure 1.

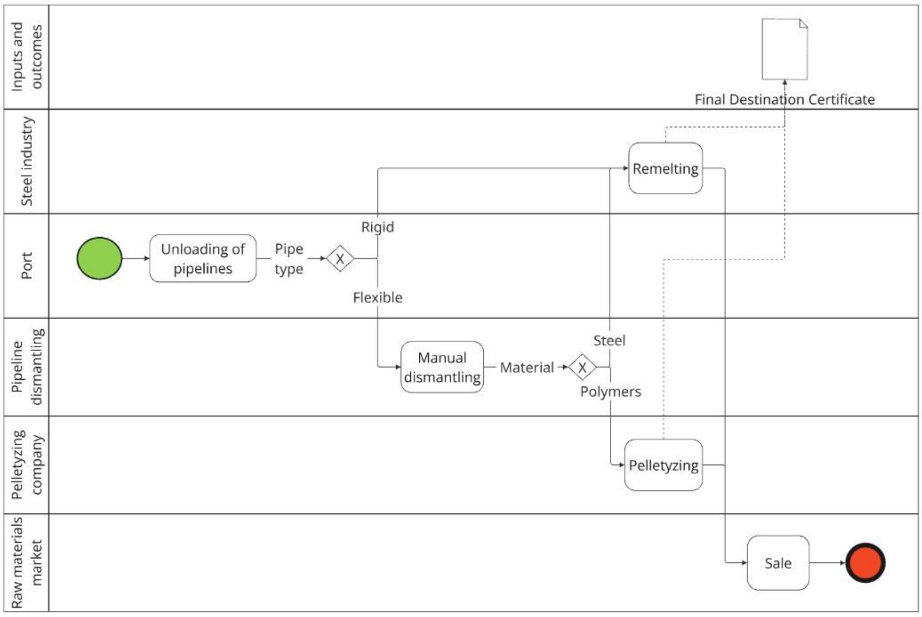

Fig. 1. Flexible pipelines dismantling flow.

To understand the flexible pipeline dismantling activities, a detailed description of the activities was carried out, based on Work Ergonomic Analysis, from direct observations made during the field visit (Guérin et al., 2001). This description, the number of workers involved and the potential risks present, as well as the average duration of the operations, the process mapping, and the observations based on the principles of activity ergonomics will be presented in the nest sessions.

3.1 Workers and teams

The dismantling activities are conducted at the pipeline unloading site by a total of 9 outsourced teams, each with a variable number of workers, adjusted according to the available space, the volume of material received, and the complexity of the tasks. The largest team consists of 31 workers, while the smallest has 8 people. The total number of workers involved in the operations includes about 70 in-house employees, mainly responsible for the movement and organization within the warehouses, in addition to 200 outsourced workers, who make up the operational core.

The distribution of functions within the teams follows a criterion based on the experience and practical knowledge of the workers. This intrinsic and visual knowledge plays an important role, as workers, based on their accumulated experience, can quickly identify the materials to be processed. All dismantling stages are 99% manual, except for the handling of large volumes, where forklifts are used.

3.2 Equipment and machinery

The company has a total of 30 forklifts, with 20 specifically allocated for use by the outsourced teams, and 10 under the management of the company itself. These forklifts are essential for moving the pipelines and other materials, reducing operation time and decreasing physical effort. To extract layers of materials the company relies on circular saws. According to the workers, the blades are changed very frequently due to wear from excessive use, and they reported the need to alter blades of different specifications, as they choose which type would be suitable for cutting each layer. The decision on which type of blade to use for the activities is made based on the tacit knowledge and experience of each worker (Leal & Lima, 2007).

3.3 Dismantling process

The operation begins with the scheduling defined by the oil company responsible for the decommissioning of the pipelines, who coordinates the logistics for the removal of the pipelines from their facilities after the auction process. From that moment on, responsibility for the material is transferred to the transport team of the Recycling Company. On average, 10 trucks arrive daily at the company's facilities for storage and dismantling. The process map generated from the data collected included all the activities performed after the pipelines are unloaded in the visited facility. The map can be observed in Figure 2.

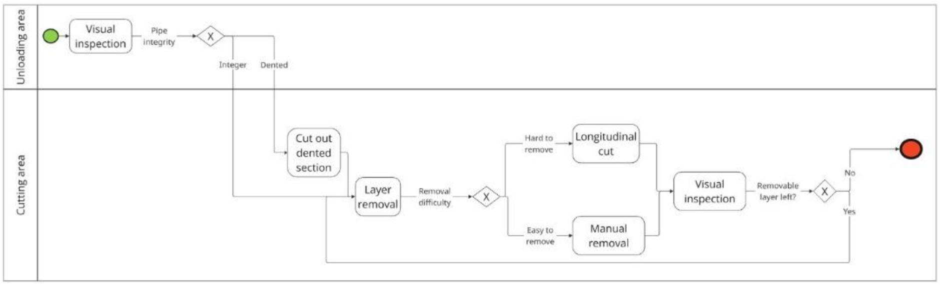

Fig. 2. Flexible pipelines dismantling process.

After the arrival of the trucks, the flexible pipes are separated and classified by size, diameter, and color in the unloading areas. Two forklift operators carry out this sorting to organize the workflow, optimizing the space and directing the materials to the dismantling teams. The time required for this step varies according to the complexity of the load, ranging from 1 to 4 hours.

Once the classification is completed, vision inspection of the pipes begins to identify deformation sources. Then, longitudinal cutting starts to remove the outermost layers, which requires the use of a circular saw, demanding physical effort and skill from the operators. If any dented areas are found, they are removed with transverse cuts. As the outer layers are removed, the process progresses until reaching the internal metal structure. At this stage, the metal wires are manually unrolled with the help of forklifts, until the metal layer is fully exposed and ready for recycling. While the metal is sent directly to the client, the core of the pipe, composed of plastic layers and other materials, undergoes a new separation stage in another warehouse. In this environment, Kevlar, nylon, and stainless steel are manually removed, while other polymeric layers go through new precise cutting processes to ensure efficient separation. In this perspective, the more complex the pipe, the greater the number of cuts and steps required, extending the duration of the process, since these lines are not accompanied by a technical document detailing their composition.

3.4 Identified hazards

3.4.1. Pipeline classification activities

Some of the activities present large variations in duration, especially those related to the classification of materials at the unloading site, which are carried out with the assistance of forklifts. In some cases, these operations can last up to 4 hours, depending on the complexity of classifying the pipelines, which imposes a significant physical load on the operators. This overload is amplified by the reliance on the workers' empirical knowledge to determine the arrangement of the pipelines, especially in situations where there are no standardized procedures to guide the execution of tasks. Additionally, the unpredictability in the time to complete the activities can result in an increase in physical effort, particularly in mechanized operations with forklifts, where the repetition of movements and the need for precision can lead to muscular and mental fatigue, as well as the risk of injury from repetitive strain.

3.4.2. Cutting activities

The cutting of the flexible pipelines' layers presented significant risks to the workers. This process is often performed without detailed planning based on technical documents and previously established procedures. In most cases, the team relies on visual analysis of the layers as the pipeline is opened. Therefore, the lack of technical documents – such as datasheets that detail the composition of the pipelines – directly impacts the safety of the process, as it forces workers to rely on their practical experience and direct observation, increasing the variability of operations and, consequently, the risk of accidents.

Additionally, the workers conduct this activity in a bent posture, using a circular saw to cut the pipeline directly on the ground, without the use of workbenches or support. This practice not only results in an unfavorable working position but also significantly increases the risk of developing musculoskeletal injuries due to the overload imposed on the spine and joints, especially when this posture is maintained for long periods. These risks are combined with the risk of serious injuries, caused by cuts to the fingers, hands, or legs.

To minimize these risks the activity requires the use of appropriate Personal Protective Equipment (PPE), including steel mesh gloves to protect the hands, a bolero apron to protect the torso, shin guards, safety glasses, masks, and ear protectors. The use of PPE would not only help prevent injuries but also protect against the inhalation of harmful particles released during cutting, such as fragments of polyamide and other microplastics present in the layers of the pipeline – as the workers observed only had facial shields without masks.

The inhalation of these particles poses a risk to the respiratory system and may, in the long term, affect the immune system and cause toxicity in other organs, as prolonged exposure to these materials can be harmful to the worker's health due to the irritating and potentially toxic nature of the substances.

3.4.3. Unrolling of the wires at the pipelines' extremities

The process requires the use of tools such as tracers (needles or pointers) to mark lines on the material, facilitating the cuts and adjustments to release the wire coiled under high pressure. However, during the handling of the tracer or even the pipeline itself, the worker is exposed to the risk of injuries due to direct contact with sharp surfaces. Blades and wires under tension present a high potential for injury, particularly to the hands, arms, and face, where contact is closer during the attempt to unroll the wire and relieve the pressure from the metal. Accidents related to exposure to such risks have already been recorded at the company, resulting in temporary absences, highlighting the need for improvements in safety practices.

3.4.4. Forklift activities

Considering that forklifts operate in areas where other activities are carried out simultaneously, one of the main issues is the risk of workers being run over. The constant movement of these vehicles in a shared environment can result in accidents, as workers in action need to move through the same spaces where forklifts are operating. In addition, there is the risk of material falling during transport and movement of loads. Forklifts handle large volumes and heavy loads. Accidental falls can result in serious and even fatal injuries, especially if the load is not properly stabilized or in case of equipment failure. In a scenario of inadequate communication between forklift operators and other workers, as well as the lack of physical barriers and proper signage, there is a risk of accidents.

4. Discussion

Based on observations made in the field, it was possible to map the risks to which workers are exposed during the execution of their activities. The identified risks are interconnected with issues related to worker health and safety, the efficiency of decommissioning and dismantling operations, and even the business model practiced. In this sense, the Ergonomic Work Analysis provides an understanding of the dynamics of activities, contributes to the organization of work, proposes alternatives to mitigate the risks of injuries and accidents, contributes to the increase of productivity in a sustainable way, analyzes postures, movements, efforts, and, most importantly, working conditions (Ferreira, 2015).

This research advances existing knowledge by addressing a topic that is still underexplored in literature, as there are no studies that specifically deal with the dismantling of flexible pipelines in the context of subsea decommissioning. The relevance of this approach becomes even more evident due to the current nature of the topic and the growing demand for efficient and safe solutions for the oil and gas industry. By exploring this area, the research helps fill a critical gap in understanding the risks involved and best practices for worker health and safety, as well as providing insights for improving dismantling operations. Thus, it was possible to analyze that the working conditions observed in this study are marked by harmful postures, repetitive movements, excessive efforts, and a high risk of accidents. These risks are primarily aggravated by the physical work environment and the predominantly manual activities, leading to direct consequences for the health of workers, process efficiency, and productivity.

In this scenario, ergonomics contributes not only to the present activity but anticipates possible variations in working conditions, preparing the environment for future adaptations. This method, which involves analyzing the activity as it is actually performed, fits within this perspective by enabling the identification of variations in work situations that may arise with changes in the process or work environment. By integrating the information gathered from risk analyses, it is possible to adjust processes more precisely to the real capacities of workers and operational conditions, respecting the margins of maneuver observed in the analyses (Bittencourt, Duarte, 2021).

To do this, practical guidelines are necessary for companies involved in the dismantling of flexible pipelines, starting with the adoption of an integrated communication approach between all parties involved, from operators to regulatory authority-ties and recycling companies, to ensure the transparency and traceability of materials. Continuous and well-structured communication between parties not only ensures that needs and expectations are met but also creates a collaborative environment that contributes to the safety of processes and the efficiency of the project (ENAP, 2017). By managing emerging expectations and addressing issues before they become problems, continuous involvement of the parties throughout the entire lifecycle facilitates compliance with environmental and safety regulations, as well as trust between the parties—a dynamic that faces challenges today (ENAP, 2017). Additionally, the use of technologies that automate some manual processes can reduce physical workload and accident risks, in line with the implementation of specific training for workers on best practices, injury prevention, use of specific equipment and task optimization.

In this context, the decommissioning and dismantling process of subsea pipelines in the oil and gas industry presents a significant challenge to the field of ergonomics, going beyond the restructuring of working conditions. This process requires a deep reflection on material reuse, the economic model of companies, and the creation of new development opportunities, considering the territory, which consists of a physical space where the simultaneous economic, cultural, and political appropriation of space occurs by groups (Du Tertre et al., 2019). End-of-life processes not only involve the cessation of activities but also the need to rethink waste management and the economic and social impacts of these transformations. The Economy of Functionality and Cooperation (EFC) proposes a new way of thinking about economic development, integrating companies, communities, and local managers cooperatively. In this model, decommissioning can be seen as an opportunity to reintegrate territories into more sustainable and resilient productive ecosystems (Du Tertre et al., 2019). However, the implementation of this approach requires a robust social and economic commitment, considering local specificities and the public policies needed to make it viable. In Brazil, where sustainability-focused policies are still consolidating, Circular Economy can generate innovation, but its effectiveness depends on a more consistent integration of economic and social dimensions and a reflection on new business models that respect the environment, workers, and meet the needs of the local Community (Lazzari et al., 2021; Lima et al., 2022).

5. Conclusion

This study aimed to explore the analysis of health and safety risks for workers in the dismantling activities of flexible pipelines originating from the decommissioning of subsea oil and gas production systems, highlighting the importance of a work-centered approach for understanding and mitigating risks during onshore operations based on the Work Ergonomic Analysis method. The information gathered points to the need for a more robust approach tailored to the Brazilian context, considering the actual conditions of operations and the complexity of the labor activities involved, from planning to the dismantling of flexible pipelines. These findings underscore the importance of real work observation to map risks to the workforce, as well as the relevance of the communication between stakeholders throughout the entire production chain, increasing transparency and traceability of recycled materials.

Nonetheless, the study was subject to time and resource constraints, which limited the scope and depth of the analyses conducted. It should also be considered that the topic of safety in the context of pipeline dismantling is still scarce in both academic and grey literature, which emphasizes the need for a more detailed understanding of the reality of work activities in this scenario. For future research, it is suggested to further deepen the Work Ergonomic Analysis in activities related to the decommissioning and dismantling of subsea pipelines and equipment, using the CAPTIV software.

This tool would allow for a more detailed evaluation of human behavior and working conditions, enabling the synchronized collection of physiological, postural, and movement data. The use of CAPTIV in subsequent studies can provide critical information on ergonomic factors, optimizing risk mapping and supporting the improvement in the health and safety conditions of workers involved in the operations. Such an approach will not only contribute to a greater understanding of real work dynamics but also to the development of solutions more adapted to the specific challenges of the oil and gas industry in Brazil.

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References

1. Baldam, R., Valle, R., Rozenfeld, H.: Business Process Management-BPM: A Reference for Practical Implementation. (2014).
2. Bittencourt, J., Duarte, F.: Contributions of Simulation in Ergonomics for Work Engineering: Methodological Perspectives and Operational Concepts. In: Braatz, D., Rocha, R., Gemma, S. (eds.) Work Engineering: Health, Safety, Ergonomics, and Design, pp. 470-474. (2024).
3. Dejours, C.: The Evaluation of Work Subjected to the Test of Reality. In: Sznelwar, L.I., Mascia, F.L. (eds.) TTO Notebooks 2. Edgard Blucher, São Paulo (2008).
4. Du Tertre, C., Vuidel, P., Pinet, C.: Sustainable Development of Territories: The Path of the Functionality and Cooperation Economy. Interdiscip. Manag. Horiz. 2(5), 1–25 (2019).
5. ENAP.: Risk, Stakeholder, and Communication Management. Available at: https://repositorio.enap.gov.br/bitstream/1/5320/4/Modulo%20IV%20%20Gerenciamento%20dos%20Riscos%2C%20das%20Partes%20Interessadas%20e%20das%20Comunica%C3%A7%C3%B5es.pdf. Accessed Nov 11, 2024 (2017).
6. Ferreira, L.L.: On Ergonomic Work Analysis or EWA. Braz. J. Occup. Health. 40(131), 8-11 (2015). https://doi.org/10.1590/0303-7657ED0213115.
7. Godoy, A.S.: Qualitative Case Study. In: Godoi, C.K., Bandeira de Mello, R., Silva, A.B. (eds.) Qualitative Research in Organizational Studies: Paradigms, Strategies, and Methods. Saraiva, São Paulo (2005).
8. Guérin, F., et al.: Understanding Work to Transform It: The Practice of Ergonomics. Blucher, São Paulo (2001).
9. Lazzari, A.G.R., Souza, A.C.A.A., Petrini, M., Aydos, M.: Sustainability and Circular Economy: The Brazilian Context in Evidence. XXIII Engena, Rio Grande do Sul (2021).
10. Leal, L., Lima, F.P.A.: "Software Factory" and the Tacit Knowledge of IT Professionals. In: III Workshop on a Socio-Technical Perspective on Software Engineering – WOSES (2007).
11. Leplat, J., Cuny, X.: Introduction to Work Psychology. PUF (1977).
12. Lima, F.P.A., et al.: Cooperative Ecosystems of Production and Service Innovation: Functionality and Cooperation Economy (FCE) and Territorial Development. School of Engineering, UFMG, Belo Horizonte (2022).
13. Martins, I.D., Bahiense, L., Infante, C.E.D., Arruda, E.F.: Dimensionality Reduction for Multi-Criteria Problems: An Application to the Decommissioning of Oil and Gas Installations. Expert Syst. Appl. 148, (2020). https://doi.org/10.1016/j.eswa.2020.113236.

14. Nogueira Hallack, L., Salem Szklo, A., Olímpio Pereira Júnior, A., Schmidt, J.: Curve-Fitting Variants to Model Brazil's Crude Oil Offshore Post-Salt Production. J. Pet. Sci. Eng. 159, 230–243 (2017). https://doi.org/10.1016/j.petrol.2017.09.015.
15. Santos, B.B., et al.: Worker Safety and Occupational Health in the Decommissioning of Oil and Gas Production Systems: A Systematic Review. Ação Ergonômica J. 18(2), 0-0 (2024).
16. Souza, K.A., Barbosa, L.C.M., Jacques, T.M.H.D.S., Bourbon, V.J.C.: New Regulatory Instrument for Brazilian Decommissioning of Oil and Gas Installations. ASCE-ASME J. Risk Uncertain. Eng. Syst. Part B Mech. Eng. 8(4) (2022).
17. St-Vincent, M., Vézina, N., Bellemare, M., Denis, D.: Ergonomic Intervention. Editions MultiMondes and IRSST (2011).
18. Wifa, E., et al.: Decommissioning, Safety, and Africa's Blue Energy Economy: An Analysis of the African Integrated Marine Strategy (AIMS) 2050. J. Sustain. Dev. Law Policy (2023).
19. Wisner, A.: Ergonomics or the Science of Work. Manole Publishing, São Paulo (1987).
20. Yin, R.K.: Case Study Research: Design and Methods. 3rd edn. Bookman, Porto Alegre (2005).