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Work and Safety in the Decommissioning of Flexible Lines

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ABSTRACT

Introduction: Workplace safety in the decommissioning of flexible pipelines from offshore oil and gas production platforms has traditionally been analyzed based on occupational health and safety indicators. However, this quantitative approach often conceals the actual working conditions in the unloading and dismantling activities of these materials. The dismantling of the pipelines integrates a developing productive ecosystem, involving companies and cooperatives that operate under intense competition and low profitability, resulting in precarious working conditions.
Objective: The study aims to analyze working conditions in the unloading and dismantling processes of flexible pipelines, expanding the focus beyond indicators and discussing strategies that promote a fairer and safer production model, aligned with the Sustainable Development Goals (SDGs).
Methodology: The research uses a qualitative and exploratory approach, combined with field observation. Based on the principles of Activity Ergonomics, working conditions were analyzed both in unloading at the port and in the dismantling of flexible pipes at a recycling company.
Results: The results indicate that safety in the post-decommissioning phases is often treated superficially, disregarding the concrete working conditions at ports and recycling centers.
Discussion: Recycling companies operate with low profit margins and precarious conditions, highlighting the need for support from oil companies to ensure a more sustainable ecosystem with decent work.
Conclusion: The adoption of a cooperative model and the revision of economic incentives are crucial for balancing occupational safety and economic viability. Ergonomics, integrated with a reevaluation of the economic model, can contribute to the consolidation of a sustainable and socially responsible production model.

Keywords: Dismantling, Ergonomics, Functionality and cooperation economy, Worker safety

INTRODUCTION

The demobilization and dismantling of offshore infrastructures are complex processes that involve significant technical challenges, high costs, and potential environmental impacts. The decommissioning of subsea systems

refers to the set of activities carried out to remove equipment and structures used in oil and gas production in the marine environment, ensuring their final disposal according to regulations and best practices (Petrobras, 2023). The dismantling of flexible pipelines involves their removal, transport, and disposal or recycling, connecting subsea wells to production units. To conduct the operations efficiently, efficient operations require proper resource allocation, financial support, and strict regulatory compliance, with a focus on sustainability, worker safety, and marine ecosystem protection (FGV, 2024).

In Brazil, after offshore decommissioning, flexible pipelines proceed to onshore stages, including unloading at port bases and dismantling at recycling companies (FGV, 2024). Health and safety risk assessments still rely mainly on indicators like fatal accident rates (Coppe, 2022), without a detailed analysis of actual working conditions throughout the production chain. This gap hinders a comprehensive understanding of the risks involved. Activity Ergonomics, based on the principles of Work Ergonomic Analysis (WEA), plays a central role in understanding and improving working conditions throughout the decommissioning and dismantling chain of flexible pipelines. By considering the variability of real situations, Work Ergonomic Analysis (WEA) makes it possible to identify risks beyond traditional indicators by analyzing the physical, cognitive, and organizational demands placed on workers (Guérin et al., 2001). Aligned with this perspective, the Economy of Functionality and Cooperation (EFC) proposes new models of interaction among companies, ports, recyclers, and workers, promoting collaboration and a more sustainable economic model in line with the Sustainable Development Goals (SDGs) (Lima et al., 2019; Silva et al., 2019). This approach supports strategies that integrate innovation, safety, and environmental preservation into the productive cycle of flexible pipelines.

METHODS

This study adopts a qualitative and exploratory approach to investigate the working conditions in the onshore stage of subsea system decommissioning, focusing on the health and safety of workers. The exploratory research aims to understand the phenomenon being studied as it presents itself in the context in which it is embedded, allowing for a detailed and interpretative analysis of qualitative data in a systemic manner (Losch, Rambo, Ferreira, 2023). Data collection was conducted through field observations in the processes of unloading the pipelines at the Port Base and dismantling at a Recycling Company. The observations followed the principles of Activity Ergonomics, aiming to capture the real dynamics of work and the interactions between workers, equipment, and the work environment (Guérin et al., 2001).

For data analysis, the perspective of Work Ergonomic Analysis (WEA) was adopted, which allows understanding the relationship between working conditions and their impact on the health and safety of workers. WEA enables the identification of risk factors and the proposal of improvements in the

work environment, considering both the technical and organizational aspects of the activities analyzed (Wisner, 1994). The goal of the study, in addition to analyzing the working conditions in the unloading and dismantling processes of flexible pipelines, broadens the focus beyond safety based on accident indicators; it also aims to promote the discussion of strategies that encourage a fairer and safer production model for those involved, aligned with the Sustainable Development Goals (SDGs) (Souza, Moraes, Barbosa, 2022), particularly SDG 8 (Decent Work and Economic Growth), which promotes safe and healthy conditions for all workers, and SDG 3 (Health and Well-being), which seeks to ensure health protection in the occupational environment (Silva & Baretta, 2022). The triangulation of the information obtained provided a broader view of the studied context, favoring a better understanding of the challenges faced and the opportunities for improvement in the onshore decommissioning process, contributing to more sustainable and safer practices in the sector.

RESULTS

Unloading of Flexible Pipelines at the Port Base

A technical visit was conducted on 16/10/2024, lasting three hours, at a Port Base located in Espírito Santo (Brazil), with the aim of understanding the operations carried out in the process of unloading flexible pipelines, through a description of the activities based on the concepts of Work Ergonomic Analysis (Guérin et al., 2001). The operator visited is dedicated to the decommissioning of flexible pipelines, focusing its operations on base services, with contracts based on operational availability, which implies variability in the volume of pipelines to be received. This type of contract differs from those adopted by other operators, which are based on the EPRD model (Engineering, Preparation, Removal, and Disposal), encompassing all stages of the decommissioning process, from planning to final disposal. The Port Base, located in Vitória Bay, in its current configuration, is exclusively dedicated to the disposal of materials from the decommissioning of flexible pipelines. The received pipelines undergo a cutting process into segments and are subsequently sent for recycling. Regarding the recycling stage, the operations and supply managers interviewed expressed concerns about the traceability of the material, particularly regarding the quantification and tracking of the materials actually reused. The lack of control mechanisms and reliable feedback on the destination of the waste raises questions about the effectiveness of recycling. Although a disposal certificate is issued when the pipelines are transferred to the recycling company, the lack of documentation proving the materials that were actually recycled and their respective destinations hinders the full tracking of the process and obtaining relevant information for the production chain. This gap in traceability compromises transparency and efficient management of the material life cycle.

During the visit, it was possible to understand the stages of each activity. The first onshore stage of the decommissioning process occurs at the port, where vessels, often of the PLSV (Pipe Laying Support Vessel) type, dock

and unload the flexible pipelines removed from subsea production systems. This operation can be performed using two main techniques: transpooling or using a crane. Transpooling involves moving flexible pipelines on reels and baskets, requiring precise and coordinated handling by the operators. The crane operation, on the other hand, uses high-capacity cranes to lift and transfer the pipelines from the vessel to the base. The stage of transferring the pipelines involves risks to worker safety, requiring the attention of operators and adequate health and safety management to mitigate the risks. The main risks of the process raised during the interviews were: dislodging of pipelines, failure in pipeline capping, and accidents with cranes. Poorly secured pipelines can dislodge and hit workers, improper capping can lead to leaks of contaminant residues, and the movement of heavy loads with cranes can cause tipping accidents or material falls. The occurrence of these events puts workers' physical integrity at risk and may cause environmental damage, highlighting the need for robust safety procedures.

In the inspection stage, conducted at the transfer area, the pipelines are visually examined to identify wear and damage to the outer coating. Next, one of the ends is untied, and a longitudinal cut is made to check for the presence of oily residues. If residues are detected, the pipeline is sent to the cleaning area; if the pipeline is clean, it is directly sent to the cutting stage. The movement of 120-ton reels between areas is completed in ten minutes, with the help of a 320-ton capacity transport vehicle (jumbo). The thorough inspection of the reels is essential to prevent contamination and ensure the safe flow of operations.

The cleaning stage of the pipelines involves removing residues and encrustations by passing a PIG driven by clean water, which may be complemented by chemical processes using diesel oil or thermal treatments. Uncertainty about the number of passes required for complete cleaning was pointed out by interviewees as a bottleneck in the process. Currently, the operator receives already cleaned pipelines, eliminating the need for cleaning procedures at the port base. However, the lack of measurement of NORM (Naturally Occurring Radioactive Material) upon arrival at the port raises concerns about potential worker exposure to radioactive residues. Regarding the pipeline cutting process, an excavator adapted with a hydraulic shear is used to section the pipelines into 6.5-meter segments, which are then transported to the Disposal Warehouse, located in another city, before being auctioned. The activity is restricted to the period between 6:30 AM and 9:00 PM due to proximity to residential areas. The main risks identified involve workers' contact with toxic residues remaining inside the pipelines and handling of sharp edges, which may cause lacerations. The absence of containment barriers on-site may also be considered a hazardous factor, as it can lead to leaks during cutting, increasing the risk of exposure to contaminants.

In the Storage stage, the final step of the process, the bins with the cut segments are transported by trucks within the base. The segments are stored in the warehouse, where they await the fiscal process before being sent to the storage park of the platform-owning company, located in Macaé

(Rio de Janeiro), until the procedures for auctioning the material to interested companies for dismantling and recycling are carried out.

Dismantling of Flexible Pipelines at the Recycling Company

The Recycling Company visited is part of the ecosystem of companies involved in the decommissioning of subsea equipment, focusing on dismantling flexible pipelines made of polymeric and metallic materials. These materials are then pelletized and processed for reuse in various products. The analysis of the pipeline dismantling process highlighted the predominance of manual labor, carried out mostly by outsourced teams organized into cooperatives. It was observed that workers perform their tasks under unfavorable conditions, requiring intense physical effort, exposed to weather conditions, with risks of cuts to hands and limbs, inhalation of gases and fumes, and contact with toxic substances. The lack of appropriate Personal Protective Equipment (PPE) and the absence of standardized work procedures increase the risk of accidents.

In summary, the activities at the company begin with the classification of flexible pipelines based on size, diameter, and color. The sections are transported by forklifts to a warehouse near the cutting station. At this point, the process of removing the external layers of the pipelines begins, using circular saws. This activity exposes workers to the risk of cuts and amputations of hands and lower limbs, as well as inhalation of toxic gases and exposure to weather conditions. Cutting directly on the ground, without support from workbenches, forces operators to adopt improper postures, which may lead to musculoskeletal problems in the long term. The absence of detailed technical documents about the composition of the pipelines forces workers to rely on their empirical experience to identify the layers of materials, increasing process variability and the potential for errors. The lack of PPE suited to the risks of the activity, such as masks, steel mesh gloves, shin guards, among others, exacerbates the health and safety risks for the workers. Progressing to the inner layers of the pipeline reveals another high-risk activity: the removal of the wire layer to separate the iron from the polymeric layer. This task requires the use of sharp tools and manipulation of the metal material under tension, posing the risk of deep cuts and lacerations.

The use of forklifts in material handling during the process generates the risk of run-overs, especially in areas with a high flow of workers. The absence of proper signage and efficient communication between operators contributes to the increased risk of accidents. Additionally, the lack of separation between work areas, vehicle circulation, and pedestrian zones heightens the likelihood of run-overs. The lack of effective safety measures may result in workplace accidents and the development of occupational diseases, leading to worker absenteeism and underscoring the need for interventions to improve working conditions.

DISCUSSION

This study aimed to analyze the working conditions in the processes of unloading and dismantling flexible pipelines in the context of the

decommissioning of subsea oil and gas production systems, expanding the focus beyond safety and health, and promoting the discussion on strategies for a more equitable and safer productive model, aligned with the Sustainable Development Goals (SDGs). The analysis of the operations revealed a significant contrast between the observed working conditions and the ideal conditions to ensure the health and safety of workers. Predominantly, activities requiring intense physical effort were performed under adverse weather conditions, with exposure to chemical, physical, and ergonomic risks. The lack of adequate infrastructure, such as cutting benches, efficient signage, and insufficient Personal Protective Equipment (PPE), increased the risks associated with the tasks, especially in recycling companies. The desired scenario involves the implementation of safer and standardized practices, in line with current legislation, focusing on minimizing work variability and creating a more structured working environment (Steenhagen, Jacques, Bourbon, 2022).

Furthermore, the decommissioning supply chain for flexible pipelines presents challenges related to risk mitigation and an economic imbalance, which contributes to the precariousness of labor. Oil companies, by disposing of decommissioned pipelines, gain financial advantages through the alienation of materials, while recycling companies face high costs and reduced revenues, limiting their ability to invest in structural improvements and workforce qualification, thus perpetuating the poor working conditions. The implementation of economic and fiscal incentives could reduce this disparity, promoting a more equitable reintegration of materials into the productive cycle (Cavallazzari et al., 2024).

Improving operational procedures and effectively applying legislation are crucial steps to ensure traceability and transparency in the disposal of flexible pipelines (FGV, 2024). The lack of control over the final destination of recycled materials compromises the credibility of the process and hinders the creation of reliable waste management indicators. Communication and collaboration between various actors in the decommissioning ecosystem, including oil companies, decommissioning companies, recyclers, and regulatory bodies, are key strategies to improve working conditions and address the ecological, social, and economic challenges of the sector in an integrated manner (Du Tertre, Vuidel, Pinet, 2019). Proposed strategies include: conducting detailed ergonomic analyses at each workstation, from unloading at the port to dismantling in recycling companies, to identify process variabilities and the inherent risks at each stage; providing technical documentation on the composition of pipelines to facilitate dismantling in recycling facilities; and developing continuous training plans for workers focused on safety, handling of hazardous materials, and proper use of personal protective equipment (PPE). The implementation of a digital platform for tracking recyclable materials is also a measure that would enhance transparency and control of the process. Cooperation among the involved parties can lead to joint solutions for work safety through the sharing of technical information and the development of technologies that reduce operational risks. This collaborative approach fosters sustainable and innovative practices in the sector. The growing emphasis on sustainability

and the circular economy in the oil and gas sector underscores the need for environmentally responsible and socially fair decommissioning (Souza et al., 2021). Achieving this requires public policies that support best practices, worker training, and the alignment of safety and health strategies with the SDGs through regulation, innovation, and collaboration.

CONCLUSION

This study shows that focusing solely on health, safety indicators, or operational failures is insufficient to improve working conditions in flexible pipeline decommissioning. The absence of detailed risk data and a systemic safety approach increases vulnerability to preventable accidents. A broader activity analysis helps understand key stages like preparation, regulation, flow management, and incident response (Daniellou, 2005). Thus, considering real work as central to analysis is key to designing situations that protect workers' health and safety while meeting economic goals (Guérin et al., 2001). The sector requires restructuring in two key areas: improving working conditions and revising economic models. A fairer model that supports material recycling, worker qualification, and equitable benefit distribution can sustain the process without compromising worker health and safety. The existing imbalance and lack of transparency in material disposal and reuse underscore the need for a collaborative reconfiguration involving all stakeholders.

The Economy of Functionality and Cooperation highlights the need for an integrated ecosystem through partnerships and open communication, improving labor conditions and enabling best practices (Lima et al., 2019). Guided by Activity Ergonomics principles, work integration becomes a key tool for enhancing worker safety and health throughout the decommissioning process (Guérin et al., 2001). It is important to highlight the limitations encountered in developing this study, such as the time available for data collection and restrictions on the possibility of continuous visits for activity monitoring. The research's episodic nature, with limited visits to certain process stages, hindered a deeper analysis and direct interventions. Future studies should focus on developing best practice guides for subsea decommissioning in Brazil, integrating safety, health, ergonomics, and sustainability. Such guidelines would support a circular economy while ensuring worker well-being, serving as a foundation for professional education and reinforcing the sector's commitment to the Sustainable Development Goals.

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