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# Analysis of The Causes of Workplace Accidents in The Oil and Gas Industry at PT X in 2023 Using The Human Factor Analysis and Classification System (HFACS) Method

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HFACS; Occupational Accidents; Fatality; Human Factors; Oil and Gas Industry; Occupational Safety.

**Abstract**
The oil and gas industry is recognized as one of the highest-risk industrial sectors due to its complex operations, hazardous technologies, and intensive interactions among human, technical, and organizational factors. Despite the implementation of occupational safety management systems, fatal workplace accidents continue to occur, indicating that conventional investigations focusing solely on human error are insufficient to identify the underlying causes of incidents. This study aimed to identify patterns of human and organizational failures contributing to fatal workplace accidents at PT X during 2023 using the Human Factors Analysis and Classification System (HFACS). A descriptive-analytical research design with a retrospective approach was employed. The analysis focused on three fatal accident cases documented in 2023 using accident investigation reports, incident records, and occupational safety performance data. Each accident was systematically classified into four HFACS levels: unsafe acts, preconditions for unsafe acts, supervisory factors, and organizational influences. The findings revealed that all fatal incidents involved causal factors across the four HFACS levels. Organizational culture, operational processes, resource management, inadequate supervision, tools and technology, communication, coordination, and planning were identified as dominant latent conditions across all cases. At the operational level, decision errors and routine violations consistently emerged as the primary active failures directly contributing to fatal accidents. These results demonstrate that workplace fatalities are primarily driven by systemic organizational weaknesses rather than isolated worker errors. Therefore, strengthening safety culture, improving supervisory effectiveness, enhancing competency management, and reinforcing risk-based operational planning are essential strategies for preventing future fatal accidents and improving sustainable safety performance in the oil and gas industry.

## INTRODUCTION

The oil and gas industry is recognized as a sector with a high level of occupational safety risk due to the complexity of its processes, the use of hazardous technologies, and intensive interactions among people, equipment, and work systems. Globally, although the implementation of safety management systems continues to improve, workplace accidents in the oil and gas industry still occur, ranging from minor incidents to fatal events (IOGP, 2023). This condition is consistent with the concept of high-reliability organizations, which emphasizes that small failures that are not systematically managed may accumulate and trigger events with serious consequences (Reason, 1997).

Safety performance indicators, such as Total Recordable Incidents (TRI), Total Recordable Incident Rate (TRIR), Lost Time Injury (LTI), and fatalities, are commonly used to describe occupational safety performance in the oil and gas industry. Data from PT X in 2023 showed that the TRIR achievement remained below the organization's tolerance threshold, while recordable incidents continued to occur throughout the year (Aliu et al., 2026; Hopf et al., 2025; Moenks et al., 2025; Naeem et al., 2026; Pereira et al., 2023). This indicates that quantitative safety indicators alone have not fully reflected the effectiveness of fundamental risk control, particularly in addressing the underlying causes of workplace accidents.

The accident pyramid data from PT X in 2023 showed that unsafe conditions and unsafe acts formed the largest proportion of incident precursors, followed by first-aid cases, medical-treatment cases, and ultimately fatal incidents (Kemper-Kelly, 2024). The frequency and severity of workplace accidents may increase as operational exposure and working hours increase. According to Reason (2008), this phenomenon supports the view that workplace accidents are not caused solely by individual errors but result from complex interactions among human, technical, and organizational elements.

It is evident that accident investigation methods focusing primarily on human error are insufficient to explain the complexity of incidents occurring in high-risk industries such as oil and gas (Abd Halim et al., 2024; Li & Chen, n.d.; Olatoye, 2026; Rahmati et al., 2025). Analytical approaches are required to identify the relationships between latent conditions established at the organizational level, supervisory weaknesses, and active failures committed during operations. The Human Factors Analysis and Classification System (HFACS) was developed to categorize accident causal factors into four hierarchical levels: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences (Wiegmann & Shappell, 2003).

Despite these contributions, several research gaps remain. Previous HFACS applications in the oil and gas industry have frequently analyzed aggregated accident databases, multiple companies, or incidents collected over extended periods. Such studies have provided valuable insights into general accident patterns; however, they may not fully explain how active failures and latent organizational conditions interact within a specific company and operational period. Conversely, some company-level studies have examined general or recordable incidents without focusing specifically on fatal accidents, even though fatal events require deeper investigation due to their irreversible consequences. Furthermore, limited studies have compared multiple fatal incidents involving different operational activities within the same upstream oil and gas organization to identify recurring causal patterns (Kursunoglu, 2026; Martarinza et al., 2026; Tayab et al., 2024; Wingate, 2023; Zakaria, 2023; Zhu et al., 2022). The three fatal incidents at PT X provide an opportunity to examine whether seemingly different accidents originate from common weaknesses in organizational culture, operational processes, resource management, supervision, equipment control, communication, and decision-making.

Addressing this gap is important because safety interventions directed only at frontline workers may result in temporary compliance without eliminating the organizational conditions that repeatedly generate unsafe behaviors. The preliminary classification of PT X

incidents showed that organizational culture, operational processes, resource management, inadequate supervision, tools and technology, communication, coordination, and planning appeared across all three fatal accident cases. Decision errors and routine violations were also identified in each case, suggesting that unsafe acts had become embedded within normal operational practices rather than representing isolated individual misconduct. Without systematic corrective actions, including competency verification, procedure improvement, strengthened field supervision, effective equipment assurance, and improved hazard communication, similar causal pathways may continue to emerge even when conventional injury-rate indicators appear acceptable.

The novelty of this research lies in its incident-based and multilevel analysis of all fatal accidents recorded at PT X during 2023 using the four HFACS levels: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences. Unlike studies that merely calculate accident frequencies or identify single dominant causes, this research reconstructs each accident event and traces the relationship between immediate operational actions and underlying systemic deficiencies. The analysis also distinguishes active failures from latent conditions and compares their recurrence across three technically different fatal incidents. Therefore, this study provides a contextual explanation of how normalized deviations, equipment inadequacies, competency gaps, poor communication, inappropriate operational planning, and supervisory failures may interact to produce fatal outcomes in upstream oil and gas operations. This approach is expected to generate findings that are scientifically relevant and directly applicable to organizational safety improvement.

Accordingly, this research aimed to identify and classify the human, technical, supervisory, and organizational factors contributing to fatal workplace accidents at PT X in 2023 through the HFACS framework. The objectives were to reconstruct the chronology of each fatal event, classify the identified causes at each HFACS level, determine the dominant active failures and latent conditions, compare causal patterns across the three incidents, and formulate system-based accident-prevention priorities. Theoretically, this study contributes empirical evidence regarding the application of HFACS in Indonesia's upstream oil and gas industry and strengthens the understanding of accidents as outcomes of interactions between frontline behaviors and organizational systems. Practically, the findings can support company management, occupational safety professionals, supervisors, contractors, and regulators in improving operating procedures, competency management, equipment assurance, hazard identification, supervision, communication, emergency preparedness, and organizational safety culture. Ultimately, this research is expected to assist PT X in moving beyond reactive accident investigation toward sustainable and preventive fatal-risk management.

## METHOD

This study employed a descriptive-analytical research design with a retrospective approach to analyze the causes of workplace accidents in the oil and gas industry during 2023. This approach was selected to examine accident patterns based on documented historical data and systematically identify contributing factors using the Human Factors Analysis and Classification System (HFACS) framework. The research design enabled an in-depth analysis of the relationship between workplace accidents and the underlying human and organizational factors.

The unit of analysis in this study consisted of workplace accident incidents recorded during 2023 at Company X in the upstream oil and gas sector. The analysis focused specifically on fatal accident cases. Each incident was treated as an individual unit of analysis to ensure consistency in identifying and classifying causal factors based on the HFACS framework.

The accident cause analysis was conducted by classifying each incident into four HFACS levels: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences. The classification process was performed through a review of accident investigation documents, incident reports, and available occupational safety performance data. Each incident could involve multiple causal factors across different HFACS levels, reflecting the interaction between active failures and latent conditions. To ensure consistency and validity, the classification process followed established HFACS categories and criteria used in occupational safety research.

## RESULTS AND DISCUSSION

PT. X is a company engaged in the upstream oil and gas sector with a wide scope of operations at home and abroad. This company manages a significant part of the national oil and gas working area and makes a strategic contribution to meeting domestic energy needs, both oil and gas. The operational activities of PT. X includes the exploration, development and production of hydrocarbons carried out through several operating regions and Subsidiaries with diverse geographical characteristics and risks.

In carrying out its business activities, PT. X is supported by an integrated organizational structure, including regional operating units and supporting entities for oil and gas support services. The high complexity of operations, the use of risky technology, and the involvement of a large number of workers make the aspects of safety, occupational health, security, and the environment (HSSE) a top priority in the management of company operations.

However, in 2023, there have been 3 fatal incidents that resulted in the death of the victim. The first incident was on January 18, 2023 when the Full Opening Safety Valve (FOSV) fell and hit workers on the Working Platform, Table 1. The second incident was on February 10, 2023 when a worker died due to a sagging Traveling Block during the work of RIH (Run In Hole) DP 2 7/8" x 176 joints + DC 4 3/4" x 4 joints + TCB 6 1/8" on the drilling rig, Table 2. The third incident was on November 5, 2023 when a worker died due to being hit by a 36-inch pipe lock, Table 1.

**Table 1. Fatality Incident on January 18, 2023**

| TIME | CHRONOLOGICAL DESCRIPTION |
|---|---|
| Wednesday, 18 January 2023 07:00–07:30 | The morning shift team arrived at the Rig and carried out a Tail Gate Meeting (TGM). |
| Wednesday, 18 January 2023 8:15 AM | Drillers and Floormen (including Injured Person/IP) headed to the working platform to reposition the air hoist. The driller took the initiative to move the air hoist to the monkey board area in preparation for the next work (ladder laydown). |
| Wednesday, 18 January 2023 8:15 AM | Floorman 1 mounted the FOSV on a 3 ton capacity air hoist hook as a ballast for repositioning. The air hoist is then lifted by Driller. Floorman 2 (IP) is on top of the working platform and performs the activity of opening the fence locking pin in a squat position. |
| Wednesday, January 18, 2023 8:29 AM | The driller lifts the hook that has been loaded with FOSV from the outside of the rig to the monkey board. Floorman 1 gives a hint from the edge of the rig floor (the end of the stairs to the rig floor). |
| Wednesday, 18 January 2023 08.30 | The hook and FOSV get stuck on the rig tower frame on top of the monkey board, causing the hook to open and the FOSV to fall. |
| Wednesday, 18 January 2023 08.30 | FOSV overrides the right body of Floorman 2 (IP). The IP suffered bleeding on his side neck and neck, as well as a fracture of his right hand. |
| Wednesday, 18 January 2023 08:31 | Floorman 1 and Driller realized IP was seriously injured and immediately called the rest of the crew for help. |
| Wednesday, January 18, 2023 8:32 AM | The rig crew and the Well Site Representative (WSR) headed to the rig floor to provide first aid. |
| Wednesday, January 18, 2023 8:35 AM | The IP is derived from the rig floor using a stretcher. |
| Wednesday, 18 January 2023 08:40 | IP was evacuated using a double cabin car to the nearest clinic with a prone position in the tail of the vehicle. |
| Wednesday, 18 January 2023 09:00 | IP was declared dead upon arrival at the clinic (*Death on Arrival / DOA*). |

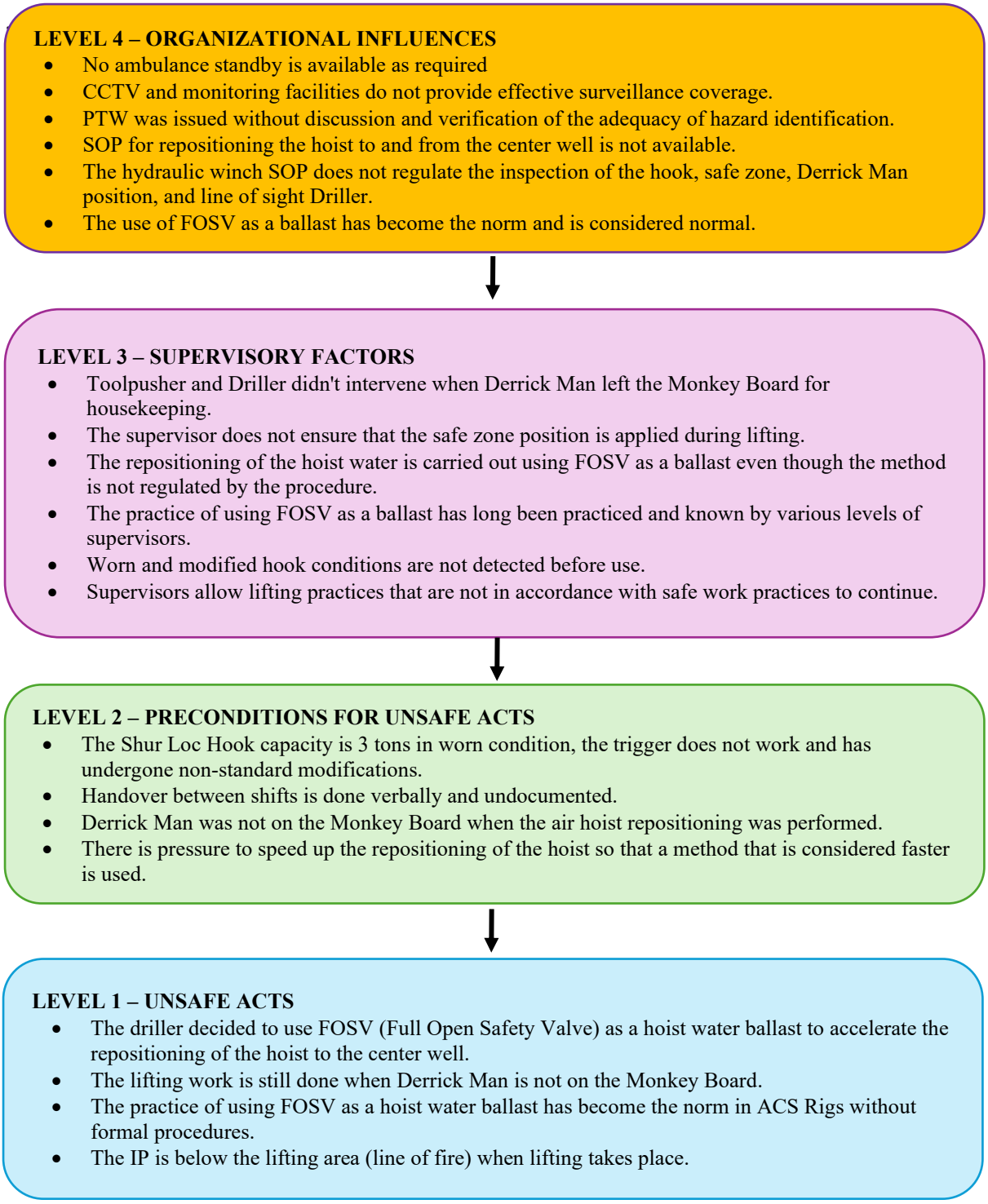



**Figure 1. HFACS Classification of Fatality Events on January 18, 2023**

**Table 2. Fatality Incident on February 10, 2023**

| TIME | CHRONOLOGICAL DESCRIPTION |
|---|---|
| Friday, 10 Feb 2023 11.00–12.00 | Dynamic observation, mud tank volume monitor, pump stop and well-static observation. This work is supervised by a company man. |
| Friday, 10 Feb 2023 12.00–12.47 | Continue to enter the series of drilling pipes from a depth of 4998.35 to 5596.37 (175 joints). |
| Friday, 10 Feb 2023 12:47 PM | Handover of drilling console operation between the Driller and the Tool Pusher is carried out after the connection of DP joint #173.<br>The traveling block dropped 15 feet, then suddenly the traveling block sagged quickly so that it fell to the rig floor, at the same time the circuit was in a position held by the elevator on the rig floor. The rig was declared to stop operation. |
| Friday, 10 Feb 2023 12:47 PM | IP-1 (Floor man) was hit by a travelling block and suffered a left head injury. IP-2 (Floor man) jumped from the floor rig to the ground (height ±5 m) resulting in a fracture of the left leg femur. |
| Friday, 10 Feb 2023 12.50 | The travelling block was lifted using a crane to evacuate the IP-1. The IP-2 was taken to the massager using the DC Rig Support car. |
| Friday, 10 Feb 2023 13.10 | IP-1 was evacuated using a Pajero Car and headed to Tanah Abang Hospital. |
| Friday, 10 Feb 2023 13.30 | IP-1 was declared dead upon arrival at Tanah Abang Hospital (DOA/Death On Arrival). |
| Friday, 10 Feb 2023 17.25–18.10 | IP funeral process. |

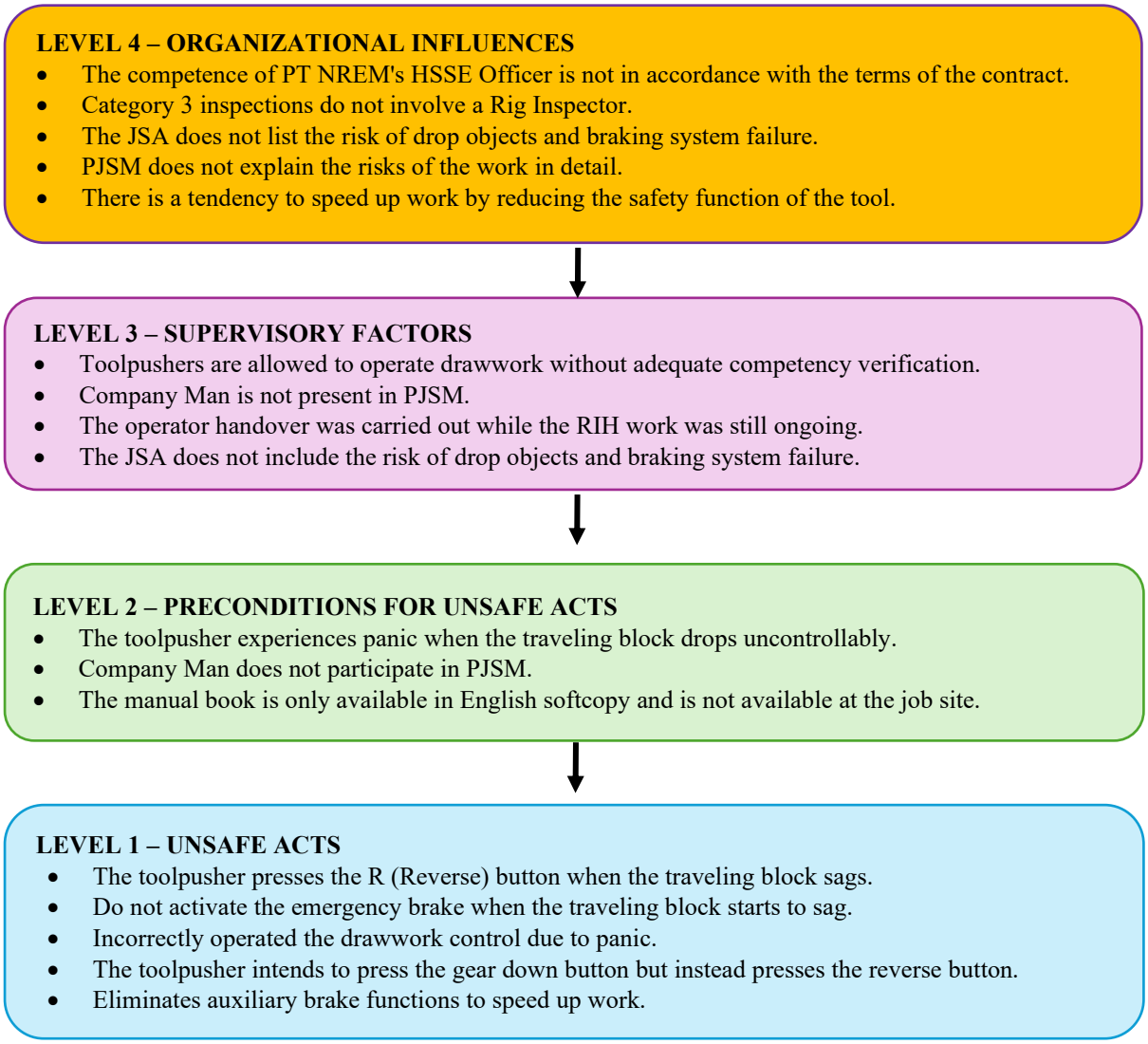


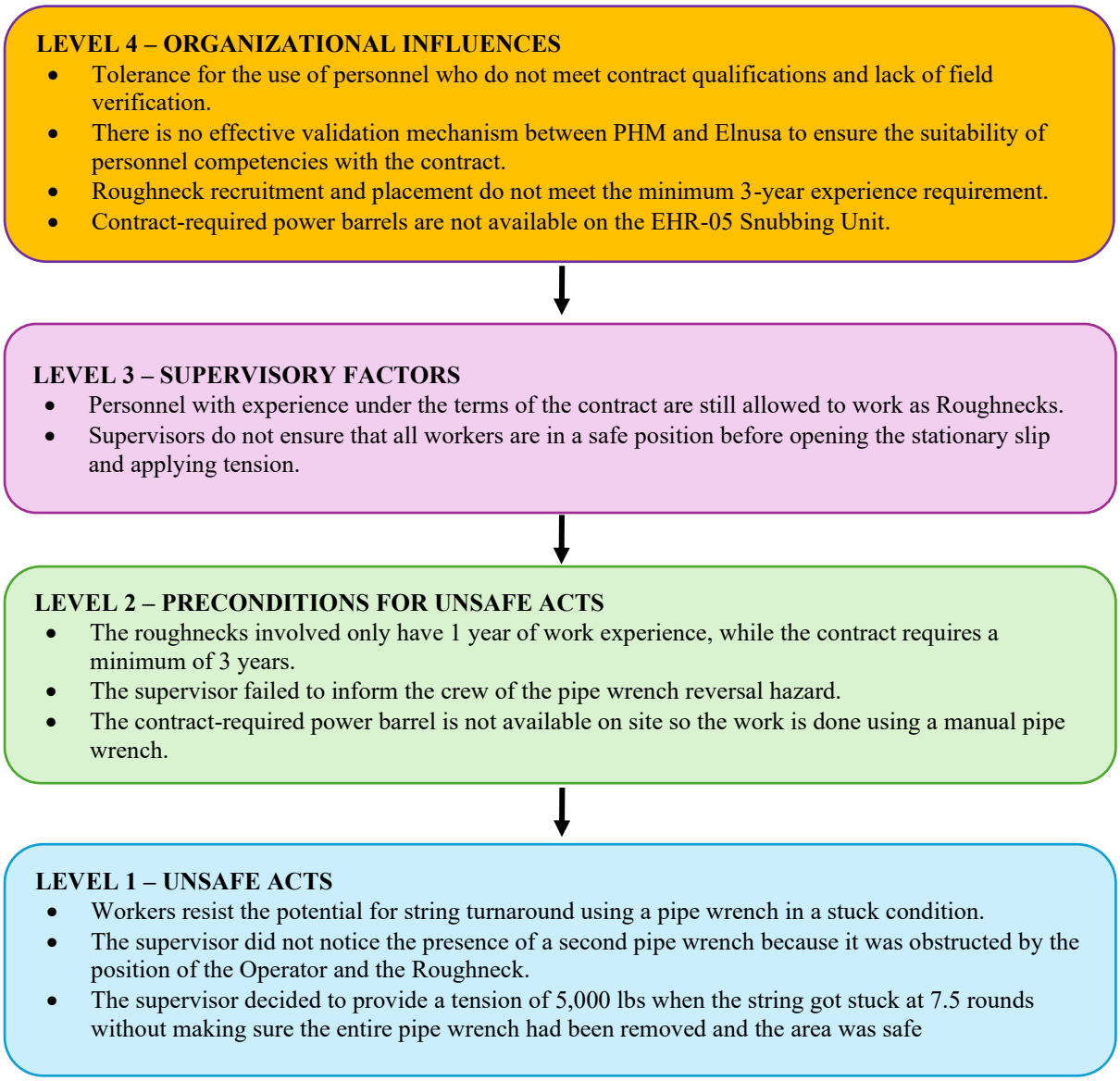

**Figure 2. HFACS Classification of Fatality Events on February 10, 2023**

**Table 3. Fatality Incident on November 5, 2023**

| TIME | CHRONOLOGICAL DESCRIPTION |
|---|---|
| Saturday, November 4, 2023 1:15 AM | Crew prejob safety meeting continued Installation/rig up Snubbing Unit above the wellhead |
| Sunday, November 5, 2023 2:45 AM | Finished rig up Snubbing Unit and function test BOP Operation of the Snubbing Unit equipment into the well. |
| Sunday, November 5, 2023 1:53 PM | When the second pipe key is removed, the macaroni and pipe lock rotate counterclockwise and hit the victim's head. |
| Sunday, November 5, 2023 1:54 PM | First aid and evacuation of victims using basket stretchers. |
| Sunday, November 5, 2023 2:32 PM | The victim was evacuated using a sea truck and arrived in Handil, examined by a doctor; There is no response, no breath and no pulse. CPR, oxygenation, AED help are performed. |
| Sunday, November 5, 2023 3:55 PM | The helicopter is ready including the installation of stretchers, Handil's trip to Balikpapan. |
| Sunday, November 5, 2023 4:15 PM | Evacuation to the hospital in Balikpapan, CPR continued during the flight. |
| Sunday, November 5, 2023 4:34 | Arriving at Sepinggan Airport |

| | |
|---|---|
| PM | |
| Sunday, November 5, 2023 4:58 PM | Arriving at the hospital, CPR was continued and an ECG was performed. |
| Sunday, November 5, 2023 5:10 PM | The victim was declared dead by a hospital doctor. |

**Figure 3. HFACS Classification of Fatality Events on November 5, 2023**



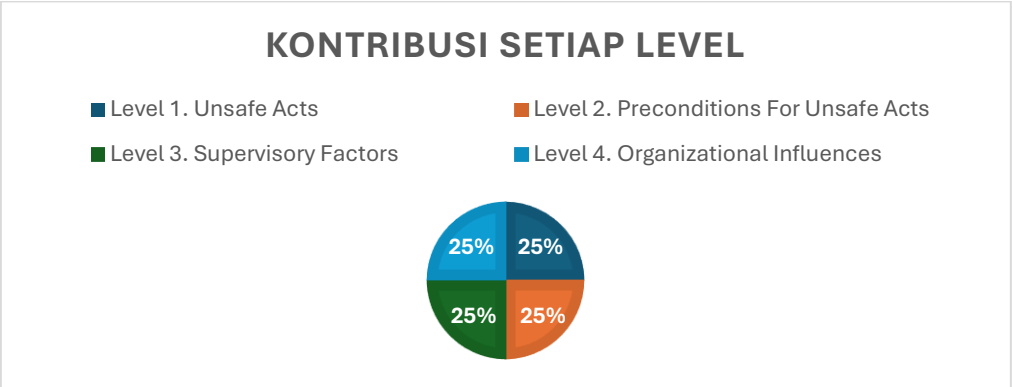



**Figure 4. Contribution of Each Level**

Based on the classification results, all fatal events showed the presence of factors at all four levels of HFACS. At Level 1 (Unsafe Acts), various unsafe actions were found that directly triggered the incident, such as the use of FOSV as a water hoist ballast, improper operation of drawwork when the traveling block sagged, and the provision of tension without ensuring a safe work area. This factor is an active failure that occurs at the front line of the operation and is the direct cause of the accident. However, these insecure actions do not appear in isolation, but are influenced by factors at the level above them.

At Level 2 (Preconditions for Unsafe Acts), conditions were found that facilitated the occurrence of unsafe acts, including improper equipment conditions, weak communication and work coordination, limited operational information, and psychological pressure at work. This factor suggests that workers often make mistakes because they work in an environment that does not fully support the safe execution of work. These findings show that technical failures and human factors interact with each other before accidents occur.

At Level 3 (Supervisory Factors), various weaknesses in supervision were found such as lack of intervention against unsafe work practices, inappropriate operating arrangements, failure to fix known problems, and neglect of procedural irregularities. Supervisors have a critical role in ensuring compliance with procedures and risk control. When the supervisory function is not running effectively, various unsafe conditions can develop into unsafe actions in the field.

At Level 4 (Organizational Influences), weaknesses were found in aspects of organizational culture, operational processes, and resource management. Some examples identified are incompleteness of work procedures, ineffective hazard identification processes, lack of verification of worker competence, limited safety support facilities, and tolerance for deviant work practices. These factors are latent conditions that are formed long before the accident occurs and are the foundation for the development of failures at the level of supervision, working conditions, and worker actions.

**Latent Conditions**

**Table 4. Percentage of Latent Conditions**

| HFACS | Subcategories | Number of Identified Cases Contributing by Factor | Percentage (%) |
|---|---|---|---|
| Level 4. Organizational Influences | *Organizational Culture* | 3 | 100 |
| | *Operational Process* | 3 | 100 |
| | *Resource Management* | 3 | 100 |
| Level 3. Supervisory Factors | *Inadequate Supervision* | 3 | 100 |
| | *Planned Inappropriate Operations* | 2 | 66.7 |
| | *Failure To Correct Known Problem* | 2 | 66.7 |
| | *Supervisory Violation* | 2 | 66.7 |
| Level 2. Preconditions For Unsafe Acts | *Situational Factors : Physical Environment* | 0 | 0 |
| | *Situational Factors : Tools/Technology* | 3 | 100 |
| | *Personnel Factors : Communication, Coordination & Planning* | 3 | 100 |
| | *Personnel Factors : Fitness For Duty* | 1 | 33.3 |
| | *Condition of Operators : Mental States* | 2 | 66.7 |
| | *Condition of Operators : Physiological States* | 0 | 0 |
| | *Condition of Operators : Physical/Mental Limitations* | 0 | 0 |

The results of the analysis showed that the most dominant latent conditions were found in the categories of Organizational Culture, Operational Process, Resource Management, Inadequate Supervision, Tools/Technology, and Communication, Coordination and Planning, which were found in all fatality cases (100%). These findings show that fatal accidents are more influenced by organizational system weaknesses than individual factors.

At the Organizational Influences level, the Organizational Culture subcategory (100%) shows a normalization of work practices that deviate from safety procedures, such as the use of non-standard work methods that are still accepted in operations. Operational Process (100%) indicates that work procedures, hazard identification, and work planning have not been able to adequately control risks. Meanwhile, Resource Management (100%) shows shortcomings in personnel competency management, equipment provision, and safety support facilities.

At the Supervisory Factors level, the Inadequate Supervision subcategory (100%) is the dominant factor that shows the failure of the supervisor to ensure that work is carried out according to procedures, control risks, and intervene in unsafe conditions. In addition, Planned Inappropriate Operations (66.7%), Failure to Correct Known Problem (66.7%), and Supervisory Violation (66.7%) indicate that most cases involve improper operational decisions and neglect of previously known problems.

At the Preconditions for Unsafe Acts level, the Tools/Technology subcategory (100%) shows that the condition or availability of equipment contributes significantly to the occurrence of fatal accidents. In addition, Communication, Coordination and Planning (100%) indicates weaknesses in work communication, coordination between personnel, and planning of high-risk activities. Mental States (66.7%) were also found in most cases, suggesting that work pressure, panic, or inappropriate risk perception also influenced decision-making in the field. In contrast, the subcategories of Physical Environment, Physiological States, and Physical/Mental Limitations were not found as factors that directly contributed to the cases analyzed.

Overall, the results of the study show that the most dominant latent conditions come from weaknesses in organizational culture, operational processes, resource management, supervision, and work communication. These findings indicate that efforts to prevent fatalities in the oil and gas industry need to be focused on strengthening safety management systems, increasing the effectiveness of supervision, controlling personnel competencies, and improving the quality of work planning and communication.

**Active Failure**

**Table 5. Percentage of Active Failure Conditions**

| HFACS | Subcategories | Number of Identified Cases Contributing by Factor | Percentage (%) |
|---|---|---|---|
| **Level 1. Unsafe Acts** | Errors : Decision Errors | 3 | 100 |
| | Errors : Skill-based Errors | 1 | 33.3 |
| | Errors : Perceptual Errors | 2 | 66.7 |
| | Violations : Routine Violations | 3 | 100 |
| | Violations : Exceptional Violations | 0 | 0 |

The results of the analysis showed that Decision Errors and Routine Violations were the most dominant forms of active failure, each found in all fatality cases (100%). These findings suggest that fatal accidents are not only triggered by errors in operational decision-making, but also by deviant work practices that have become the norm in the execution of work. This condition can be seen from the use of work methods that are not in accordance with standards, improper operation of equipment, and neglect of hazard control in high-risk work areas. These mistakes and violations are the direct triggers for uncontrolled energy releases that lead to fatality.

The Perceptual Errors subcategory was found in 66.7% of cases, indicating that some workers had a failure to recognize or interpret rapidly evolving working conditions. This factor causes workers to be unable to identify hazards appropriately so they take actions that are not in accordance with the actual conditions in the field.

Meanwhile, Skill-Based Errors were only found in 33.3% of cases. These findings indicate that a small proportion of accidents are affected by skills errors or operational errors while performing tasks. The low proportion of these factors suggests that most fatal incidents are not caused by the lack of technical skills of workers, but rather by improper decisions and work behavior that deviates from safety procedures.

No Exceptional Violations were found in all cases analyzed. This shows that the violations that occur are not extraordinary acts or incidental irregularities, but violations that

have become part of daily work practices (routine violations). These findings indicate a normalization of deviations in the work environment that allows unsafe practices to occur repeatedly without adequate correction.

## CONCLUSION

The latent conditions identified in this study were dominated by Organizational Culture, Operational Processes, Resource Management, Inadequate Supervision, Tools/Technology, and Communication, Coordination, and Planning, which were present in all fatal accident cases (100%). These findings indicate that the root causes of fatal accidents were not solely related to workers' actions in the field but were also influenced by weaknesses in organizational systems, supervisory practices, resource management, equipment availability, and communication and operational planning processes. These latent conditions contributed to the creation of a work environment in which deviations and failures in risk control could develop before accidents occurred.

Meanwhile, active failures were dominated by Decision Errors and Routine Violations, which were identified in all fatal accident cases (100%). These results indicate that fatal accidents in the oil and gas industry were frequently triggered by inappropriate operational decisions and unsafe work practices that had become normalized during work execution. The presence of Perceptual Errors in most cases also suggests that workers experienced difficulties in identifying and responding appropriately to hazardous conditions. Therefore, the fatal accidents analyzed in this study resulted from interactions between latent conditions embedded within the organizational system and active failures occurring at the operational level, consistent with the HFACS framework.

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