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Analysis of Factors Influencing Work Accidents Among Workers at Exploitation Facilities and Offshore Oil and Gas Production at PT X from 2018 – 2023

Cahyo Hardo Priyoasmoro[1]*, Zulkifli Djunaidi[2]

[1]Department of Occupational Safety and Health, Faculty of Public Health, University of Indonesia | email hardo1973@gmail.com

[2]Department of Occupational Safety and Health, Faculty of Public Health, University of Indonesia | email zul@ui.ac.id

* Corresponding Author: hardo1973@gmail.com

ABSTRACT

Background: The workplace risks faced at PT X oil and gas company, located offshore Natuna, are relatively high evidenced by fluctuations in accidents from 2018 – 2022. In 2018, recordable injury attributable to accidents was recorded, then in 2019-2020, there were no accidents, and the prevalence increased in 2021-2022. The company analyzed the main causes responsible for work accidents during this period and carried out intervention measures in Occupational Health and Safety (OHS) program to reverse the trend in 2023. By implementing OHS program, the number of accidents in recordable injury category fell from 4 (2021- 2022) to 1 (2023). This shows that the program has been successful in managing work accidents. Considering that the investigation and analysis identified unsafe acts as the direct causes, Human Factor Analysis and Classification System (HFACS) method was used to analyze other factors associated with accidents.

Objective: This study aimed to investigate OHS program actions at PT X in responding to increased work accidents in 2021-2022, and compare with recommendations for improvements from HFACS method.

Method: A qualitative design was used with secondary data, comprising 10 work accidents records and investigation reports for recordable injury cases from 2018 – 2022 available in PT X information system. Subsequently, the secondary data were then classified according to four failure stages in HFACS, namely unsafe acts, the precondition of unsafe acts, unsafe supervision, and organizational influence. This classification produced recommendations for improvement, which were then compared with the prevention intervention program for accidents at PT X.

Results: The results showed that OHS program intervention to reduce the number of accidents in 2023 was in accordance with the recommendations of HFACS analysis.

Conclusion: The application of HFACS in analyzing accidents records and investigation reports produced relatively comprehensive recommendations by focusing on the component stages. Several additional recommendations from the analysis of latent conditions will further improve OHS performance at PT X.

Keywords: Work-Related Accidents; Recordable Injury; TRIR; HFACS; Latent Condition; Occupational Health and Safety (OHS)

INTRODUCTION

PT X is an oil and gas exploration and production company in Indonesia with operational areas in Natuna Sea. The core activities on offshore platform comprise managing the production and shipment of oil and gas, which include supervising operational interventions by the operators. Additionally, the company performs maintenance work with local workers and hires specialized personnel for tasks requiring specific expertise. This includes the maintenance of gas turbines, generators, custody measuring devices, oil meter calibration tools, radar on the FPSO, well maintenance or service, structural and pipeline integrity maintenance, drilling activities, and others.

From 2018 – 2023, PT X experienced significant fluctuations in the occurrence of workplace accidents. The COVID-19 pandemic in 2020 impacted activities supporting production. Consequently, the focus shifted to essential maintenance for safety and production-critical equipment, leading to the absence of recordable injury accidents. In 2021, after the COVID-19 pandemic subsided and many workers were immunized, production support activities increased. This led to prolonged daily working hours corresponding to a rise in work accidents.

Based on available data, recordable injury include the total accidents from the categories of Lost Time Incident (LTI), Lost Work Day Cases (LWDC), Restricted Work Day Cases (RWDC), and Medical Treatment Cases (MTC). In general, work accidents in recordable injury category have increased at PT X since 2021. As stated by the International Association of Oil & Gas Producers [18], recordable injury rate in the company was estimated at 0.90, which was 17% higher than the value obtained in 2021 (0.77). Furthermore, IOGP member companies reported 682 cases of lost workday cases (LWDC) or restricted workday cases (RWDC), including 514 and 168 cases among contract and regular workers, respectively. In general, the pattern of accidents leading to recordable injury at PT X from 2018 to 2023 is shown in Figure 1, with no case occurring in 2019 and 2020.

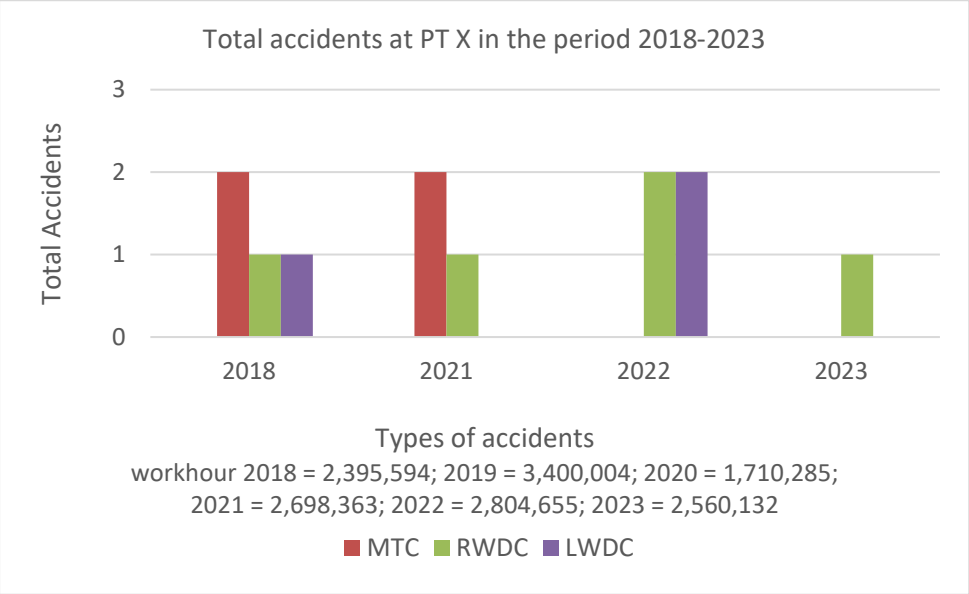

Figure 1. Recordable injury work accidents profile at PT X from 2018 - 2023.
Description: LWDC = Lost Work Day Case; RWDC = Restricted Work Day Case; MTC = Medical Treatment Case.

Figure 2 showed that the number of accidents increased after 2020 and then decreased in 2023. After implementing in OHS program, the number of recordable injury accidents was successfully reduced from 4 (2021-2022) to 1 (2023), or Total Recordable Incident Rate (TRIR) decreased from 1.4 to 0.4.

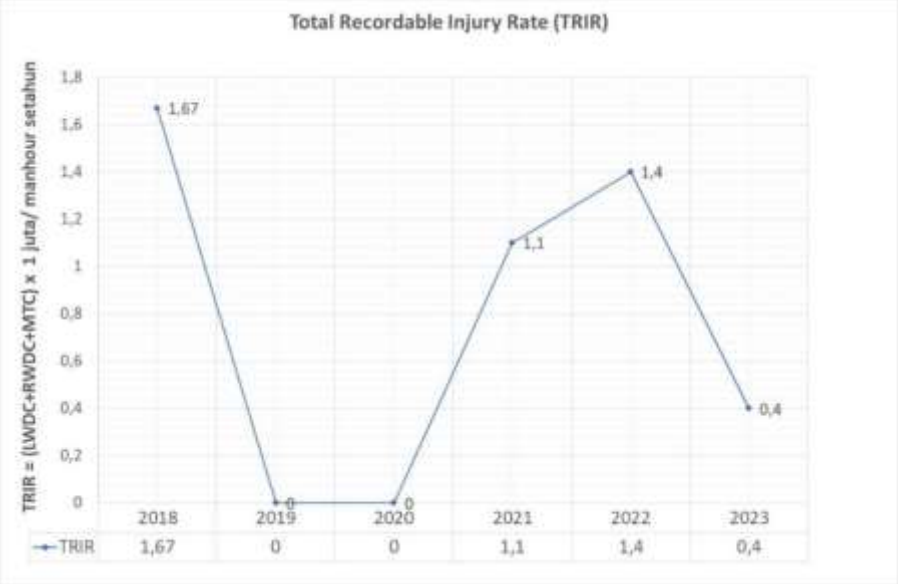

Figure 2. Total Recordable Injury Rate at PT X from 2018 to 2023.

Types of Work Accidents

According to IOGP [18], the types of human-related work accidents outcomes are categorized into five, including Fatality (LTI) or death cases, Lost Work Day Case (LWDC), Restricted Work Day Case (RWDC), Medical Treatment Case (MTC), and First Aid Case (FAC). LTI occurs when one or more people die due to a work-related incident. 'Delayed' deaths must also be reported and recorded when the primary cause is associated with accidents.

LWDC refers to non-fatal cases that lead to the victim being unable to perform any work on the day following work accidents. This includes rest days, weekends, vacation days, national holidays, or days after quitting work. RWDC refers to cases that do not lead to death or lost work days but render an individual unfit to perform regular work fully on the day following work accidents. Possible tasks may include temporary assignments, part-time or full-time work in regular jobs but not performing all job duties.

MTC refers to cases that are not reported as fatalities, lost workday cases, or restricted workday cases, but are more severe than first aid cases (FAC). An incident is classified as MTC when management and patient care are required to address injury beyond all FAC measures. Examples of FAC actions include using over-the-counter medications, applying wound coverings namely bandages, gauze, as well as cleaning, rinsing, or soaking wounds on the skin surface.

Models of Work Accidents

The prevention of accidents is the most fundamental in safety management, in other words, when safety management is effective, accidents should not occur. In reality, accidents are complex events, rarely caused by a single failure. This complexity has posed a challenge to understanding accidents causation since the early days of the Industrial Revolution.

To uncover the mystery of factors causing accidents, studies have developed conceptual models over the years. These models have several common themes, for example, the linear model suggests a sequential relationship where one factor leads to the next, culminating in accidents. On the other hand, the non-linear complex model hypothesizes multiple factors occurring simultaneously and with a combined influence. Some models are effective in providing a theoretical understanding of accidents causation, while others are useful for supporting investigations, systematically analyzing the causal factors, and facilitating effective corrective actions [5].

The history of accident models can be traced back to the 1920s through three different phases namely simple linear, complex linear, and complex non-linear models [5]. Each model has respective assumptions, for example, the simple linear model assumes that accidents are caused by a series of sequentially interacting events or conditions. Therefore, accidents can be prevented by eliminating one of the causes in this linear sequence. Examples of the model include the domino model by Heinrich [6] & Bird and Germain [2]. The complex linear model posits that accidents originate from a combination of unsafe acts and latent hazard conditions in the system, following a linear path. Factors most distant are associated with organizational or environmental actions, while the most obvious factors are humans. In this context, the assumption is that accidents can be prevented by focusing action on strengthening barriers and defenses. Examples of complex linear model include Swiss Cheese Theory from Reason [14] and the time sequence theory from Benner [1].

The new generation of accident modeling has shifted to non-linear accident models, where accidents are considered a result of interacting variables that occur in a real-world environment. Accidents can only be adequately understood and prevented by understanding the combination and interaction of several factors associated [5]. The complex linear accident prevention model is a further development of the simple sequential model, which increasingly incorporates developmental factors into the sequential path. This method aims to identify and eliminate the root causes, or to place barriers to prevent causes of accidents.

A key model developed during the evolutionary period is the systemic model by James Reason [14]. It presents Swiss cheese model arranged in such a way that each slice of cheese is an analogy to defense systems against existing hazards to prevent accidents. In this theory, Reason categorized errors into active failures and latent conditions. Active failure is an unsafe action performed by people who have direct contact with the system, including slipping, tripping, falling, making mistakes, and procedural violations. This failure is prevalent among system operators, aircraft pilots, car drivers, train engineers, or forklift drivers in a warehouse. It is attributable to incompetent workers, substandard working conditions (such as excessive heat or noise), or engaging in substandard work activities, including disabling factory safety systems without permission, working against procedures, and others. Meanwhile, latent conditions may remain inactive in the system for years before being combined with active failures and local triggers to cause accidents. Compared to active failures, whose specific forms are often difficult to predict, latent conditions can generally be identified and rectified before adverse events occur. This understanding will lead to proactive risk management [14]. Examples of latent conditions include inadequate training, insufficient equipment and gear, gaps in supervision, undetected production defects or maintenance failures, unenforceable procedures, inappropriate automation, non-ergonomic plant design or considering human factors, management attitudes or culture prioritizing production over safety, as well as management prioritizing cost efficiency without considering the effects on safety aspects [14].

In general, latent conditions can originate from strategic and other top-level decisions made by governments, regulators, manufacturers, designers, and organizational managers. The impacts of these decisions spread in the organization, shaping distinctive corporate culture and creating factors that lead to errors in each workplace. Although active failures tend to be specific to particular accidents, latent conditions when left undiscovered and unaddressed can contribute to a variety of different accidents. Latent conditions increase the likelihood of active failure by creating local factors that encourage errors and violations. These conditions also worsen the consequences of an unsafe act by affecting the defense systems, barriers, and safeguards [14].

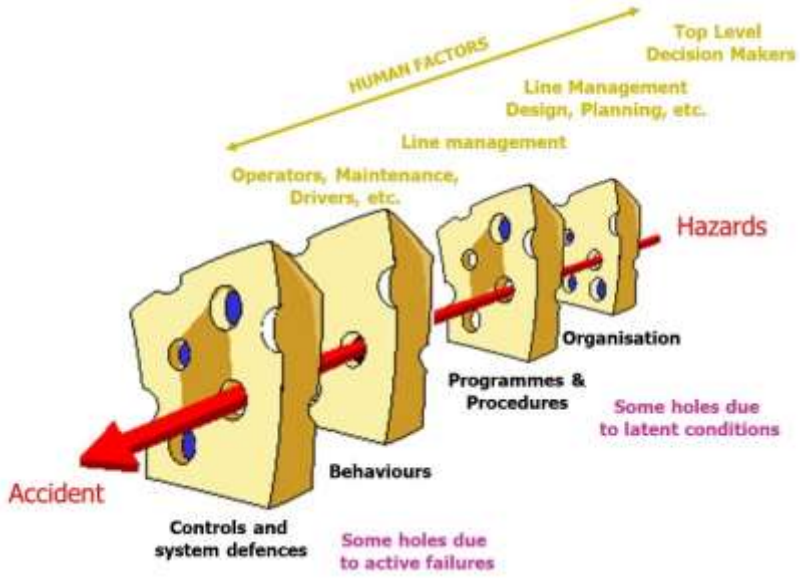

Figure 3. Swiss Cheese Theory Model from Reason (modified from Reason)

In Swiss Cheese Theory represented in Figure 3, every slice of cheese has holes in some parts, symbolizing imperfections or weaknesses in the defense system. When these imperfect conditions exist in every defense, then the presence of hazards has the potential to cause accidents, specifically in specific conditions where all the holes arrange to form a direct pathway from danger to accidents.

Human Factors Analysis and Classification System (HFACS)

Compared to Heinrich (1931) & Bird and Germain (1985) models, Reason's Swiss Cheese Theory does not specify what the holes or various layers represent. This flexibility allows OHS professionals to identify and analyze specific factors causing vulnerabilities in the organization [5].

HFACS was specifically developed to define latent conditions and active failures outlined in Reason's Swiss Cheese model, thereby serving as a tool for the investigation and analysis of accidents [20]. HFACS method has been applied in various companies such as aviation, healthcare, railways, maritime, construction, mining, and oil and gas [8,12,20]. It explains four stages of failure, each related to one of the layers found in Reason's Swiss Cheese model, namely 1) Unsafe Acts, 2) Pre-condition of Unsafe Acts, 3) Unsafe Supervision, and 4) Organization Influences. Unsafe Acts represent active failure, while Pre-conditions for Unsafe Acts, Unsafe Supervision, and Organizational Influences represent latent conditions. The following is a breakdown of four failure stages based on HFACS [20]:

Stage 1: Unsafe Acts, which are divided into errors and violations. Errors are divided into decision, skill-based, and perceptual. Meanwhile, violations are divided into routine and exceptional.

Stage 2: Pre-conditions for unsafe acts are divided into situational factors, conditions of operators, and personal factors. Situational factors consist of the physical environment and tools/technology, while conditions of the operator include adverse mental and physiological state, as well as physical/mental limitations. Personnel factors are divided into Communication, Coordination, Planning, and Fitness for Duty.

Stage 3: Unsafe supervision is classified into inadequate supervision, planned inappropriate operations, failure to correct problems and supervisory violations.

Stage 4: Organizational influences are divided into resource management, organizational climate, and organizational processes.

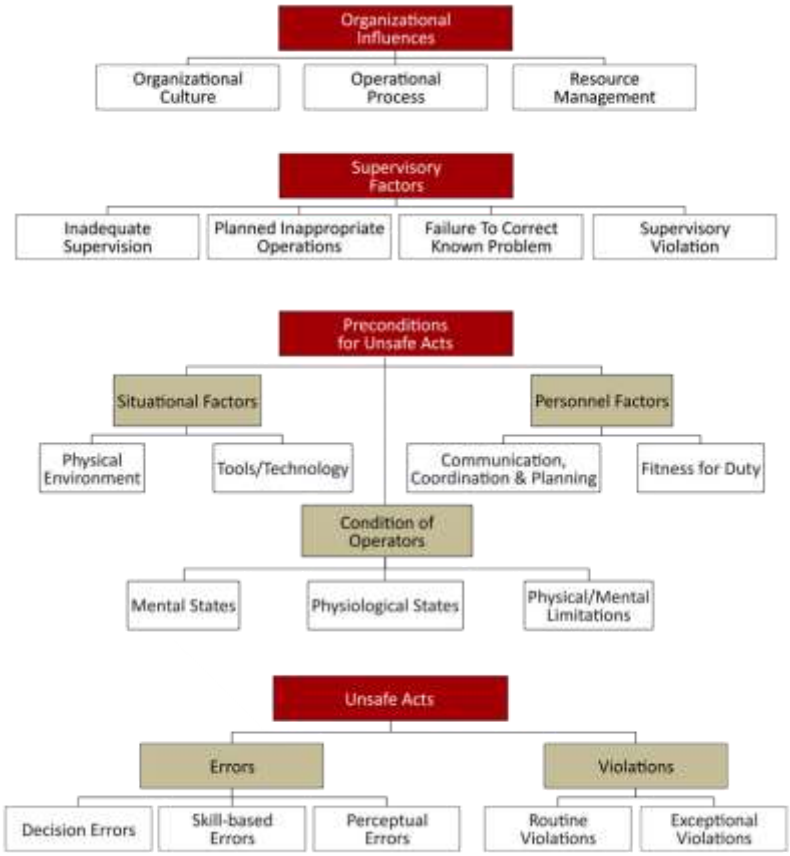

Figure 4. Four Stages of Failure in HFACS.

According to Nwankwo [12], HFACS for oil and gas company adds several aspects to each stage of failure. For violations, the act of sabotage is added, while in the Precondition for Unsafe Acts stage, under Situational/Environmental Factors, Contractor Environment is included. In the Organizational Influences stage, Management of Change and Process Safety Culture are added. Finally, this method adds Regulatory and Statutory

Influences, which consist of two aspects namely International Industry Standards and National Regulatory Framework. Furthermore, Nwankwo [12], using HFACS for oil and gas company based on IOGP database on fatal accidents from 2013 to 2017, which included 184 accident cases reported significant results. Organizational process factors contributed to 86% of accidents, while 77% were caused by tools/technological factors. Crew resource management/communication, coordination, and planning contributed to 57% with organizational climate accounting for 68%. Skill-based errors and fitness for duty readiness accounted for 53%, while routine violations contributed to 50%.

Khodijah [10] in a study on oil drilling accidents in 2022 concluded that the most common failure factors were supervision violations (100%) and physical environment (100%). Furthermore, organizational process and perceptual errors contributed 67%. The investigation and analysis of accidents at PT X showed that the direct cause was unsafe acts. Therefore, studies using HFACS were conducted to analyze other factors in the method contributing to accidents. Recommendations from this analysis would be compared with OHS accident prevention program at PT X. HFACS specific to oil and gas company [12] was not selected because there were no accidents at PT X caused by sabotage actions, related to process safety, or management of change. Consequently, the general HFACS was considered sufficient for use.

Intervention Program PT X Occupational Health and Safety (OHS) in Preventing Work Accidents.

PT X Occupational Health and Safety (OHS) Intervention Program to reverse the accident trend can be summarized as follows: 1) Implementing the B2B program, including a complacency management program. 2) Strengthening contractor induction/site familiarization before work (instilling company expectations regarding OHS including stop work authority), conducting interviews (with supervisors and key personnel) from contractors to ensure contractor competence including behavior assessment before moving offshore. 3) Implementing fatigue management. 4) Conducting quality control and quality assurance audits and establishing a quality management system. 5) Strengthening supervision with every job being adequately supervised for 24 hours.

The Back to Basic (B2) program implemented by PT X, which comprises aspects such as Respect Hazard, Contractor, Follow Procedure, and Weak Signal aims to refresh the fundamental concepts of OHS. Each aspect has respective modules, explained through presentations and discussions with offshore workers. These workers are divided into several groups and attend B2B classes with approximately 2 hours for each module. The target audience includes all regular and contract workers at offshore production facilities. Each B2B module assigns tasks to all workers to observe the facility's conditions and report to supervisors, including feedback, questions, or concerns about work practices or field conditions. Finally, the results are then collected, processed, prioritized, and followed up by relevant departments or parties, with periodic reporting.

METHOD

This study used a qualitative design with secondary data, which consisted of 10 workplace accidents records and investigation reports for recordable injury cases from 2018 – 2022 available in the information system of PT X. The secondary data were classified according to the four failure stages in HFACS, namely unsafe acts, precondition of unsafe acts, unsafe supervision, and organizational influence, followed by recommendations for improvement. The recommendations from HFACS were then compared with accidents prevention intervention programs at PT X.

RESULTS

Table 1. Results of HFACS Analysis on Accidents at PT X

No	Year & Type of Accident	Unsafe Acts	Precondition for Unsafe Acts	Unsafe Supervision	Organizational Influence	Recommended Occupational Health and Safety (OHS) interventions are based on findings in HFACS stages	Is it included in PT X Occupational Health and Safety (OHS) interventions in 2023?
1	2018 (MTC). Contractor worker accidents on support vessel.	Routine Violation. The worker's right footstep does not fully step on	Adverse mental state, namely complacency. Routine/monotonous activities can cause someone to pay less attention to tasks. Workers	Not found.	Organizational Process. Lack of procedures regarding routine/general activities.	Program to reduce Complacency. General/routine activity procedures are created socialized and	**Already.** Complacency is included in the B2B program. Implemented in 2018.

No	Year & Type of Accident	Unsafe Acts	Precondition for Unsafe Acts	Unsafe Supervision	Organizational Influence	Recommended Occupational Health and Safety (OHS) interventions are based on findings in HFACS stages	Is it included in PT X Occupational Health and Safety (OHS) interventions in 2023?
		the stairs (only using the right heel results in body imbalance when descending the stairs). The practice of ascending and descending stairs with the principle of 3-point contact is not implemented.	often go up and down the stairs of the engine room every day to perform routine tasks.			implemented on support vessels. Support ship visitation program by management to share Occupational Health and Safety (OHS) information and leadership engagement	
2	2018 (MTC). PT X workers are allergic to dust in the new office.	Decision errors. The worker entered a room where construction work was still being carried out where the dust caused allergies even though the worker had a history of allergies since childhood.	Situational factors, namely the physical environment. The condition of dusty construction workspaces that can trigger allergies is unknown to workers who have allergies. Situational factors, namely tools/technology Workers are given masks that do not comply with dust specifications, and masks are not always worn indoors by workers	Failure to Correct a Known Problem. Masks that do not meet specifications but are still used. Failure to correct inappropriate behavior/identify risk behavior. Workers whose masks are opened and closed are not reprimanded.	Organizational process, namely the absence of procedures/work permits to enter areas/rooms where construction work is still underway.	Creation of procedures for permits to enter construction areas. This procedure requires risk assessment and management. Replace masks according to work conditions. Reprimand supervisor for enforcing rules.	Implemented in 2018. Implemented in 2018. Implemented in 2018.
3	2018 (RWDC). Worker sprained ankle.	Perceptual error. The worker is wearing prescription safety glasses for the first time and when going down the stairs, the worker feels the feet are stuck to the floor, but in fact, there is still a distance between the steps and the	Situational factors, namely tools/technology Workers do not understand that using prescription safety glasses for the first time requires calibration between vision and reality before using in daily activities because of the effects of depth perception problems from these glasses.	Not found.	Organizational process, namely there is no procedure for using prescription safety glasses for the first time.	Socialization of how to use prescription safety glasses for the first time to all workers. It is recommended that this be included in the induction program for all workers going offshore.	Implemented in 2018. **Does not** include Occupational Health and Safety (OHS) intervention program.

No	Year & Type of Accident	Unsafe Acts	Precondition for Unsafe Acts	Unsafe Supervision	Organizational Influence	Recommended Occupational Health and Safety (OHS) interventions are based on findings in HFACS stages	Is it included in PT X Occupational Health and Safety (OHS) interventions in 2023?
		floor leading to a foot sprain.					
4	2018 (LWDC). Contractor workers work accidents on maintenance work	Routine Violations. The worker took a shortcut by touching v-belt which was still in motion. Workers do not wait until v-belt stops completely. Perceptual error. Workers assume work is low risk and, hence, do not need a job risk assessment (JRA).	Adverse mental state, namely complacency. The danger of v-belt movement during standby is considered a low danger or no significant danger and this condition has occurred since the Platform started production (2001). Consequently, workers become complacent, do not pay serious attention, nor carry out the risk assessment process properly.	Failure to Correct Problem. The supervisor was aware of the defective design and unsafe maintenance work practices, but no action was taken to correct it due to complacency – several years of operation without any accidents in the work area.	Resource Management – Failure to correct design flaws. Organizational process. The work permit procedure requires that all work that falls in the medium and high-risk criteria must undergo job risk analysis (JRA). JRA was not carried out because the accident was perceived as low risk.	Reprimand the contractor to work safely and according to procedures and ensure that only competent workers can be sent offshore. Fixed design flaws Improve work procedures that require All work to be carried out by JRA or create a standardization process for determining the low risk of a job Program to reduce Complacency. Program to reduce at-risk behavior.	Implemented in 2018. Implemented in 2018. **Does not** include Occupational Health and Safety (OHS) intervention program. **Already**. Complacency is included in B2B program. **Already**. The issue of contractor at-risk behavior has also been included in the company's Occupational Health and Safety (OHS) intervention program.
5	2021 (MTC). PT X worker fell at the work site.	Decision errors. The operations worker fell after entering an area to pick up work equipment (to erect scaffolding) left by the previous worker and tripped over the stiffener deck on the FPSO.	Adverse mental state, namely complacency and loss of situational awareness.	Not found.	Resource Management. There is no adequate storage space for contractors/scaffolders to store scaffolding equipment.	Train workers to have better situational awareness and risk assessment. Provide storage for scaffolding equipment Program to reduce Complacency	Implemented in 2021. Implemented in 2021. **Already**. Complacency is included in the B2B program.

No	Year & Type of Accident	Unsafe Acts	Precondition for Unsafe Acts	Unsafe Supervision	Organizational Influence	Recommended Occupational Health and Safety (OHS) interventions are based on findings in HFACS stages	Is it included in PT X Occupational Health and Safety (OHS) interventions in 2023?
		There is wider and safer access to enter the area but the operations worker chose to use the narrow and risky access, where tripping occurred. The risk assessment workforce is inadequate. Decision errors. Scaffolding workers place equipment around the workplace instead of putting it in storage.					
6	2021 (MTC). A catering contractor worker injured his finger while preparing food	Exceptional Violations. Catering workers cut frozen meatballs without thawing first according to procedures.	Adverse mental state, namely the motivation of workers to provide meatballs quickly without thawing first (from frozen conditions) because there is a request from other workers to make meatballs quickly.	Not found.	Resource Management. The correct cutting gloves (as PPE) (cut resistant/Kevlar or similar) for cutting meatballs are not available. Organizational Process. Food preparation procedures only state the requirements for using cut-resistant gloves (wire chain gloves) for butchering meat/poultry. Organizational Climate – Culture. The contractor did not dare refuse the workers' request.	Reprimand the contractor for violations & refresh food preparation procedures (including the thawing process). Provide properly cut gloves. Revise food preparation procedures in terms of the use of cutting gloves to also cover cuts other than meat and poultry. Refreshing the Stop Work Authority policy to Say NO or not accept requests if it is not possible to implement or	Implemented in 2021. Implemented in 2021. Implemented in 2021. Implemented in 2021 and included in the intervention program in 2023, namely in the induction program before

No	Year & Type of Accident	Unsafe Acts	Precondition for Unsafe Acts	Unsafe Supervision	Organizational Influence	Recommended Occupational Health and Safety (OHS) interventions are based on findings in HFACS stages	Is it included in PT X Occupational Health and Safety (OHS) interventions in 2023?
						complete in a short time.	working offshore.
7	2021 (RWDC). Contractor workers experience low back pain when doing manual handling.	Skill-based errors. Workers do not realize that an awkward position (half squatting) can cause back injury.	Adverse Physiological State. Workers are exhausted due to lack of sleep due to poor quality mattresses in accommodation (sagging mattresses), and unable to support the hip area.	Inadequate Supervision. Manual handling refresher training (including body stretching) has been carried out but the quality is inadequate. There is no risk assessment (including ergonomic assessment) for manual handling work. Supervisory Violations. The supervisor at the location does not lead body stretching before carrying out manual handling activities according to procedures.	Resource Management. Poor quality of old mattresses in accommodation (sagging mattresses).	Conduct training for workers regarding awkward positions and dangers. Replace the mattress with a good type and check the condition of mattresses at other production facilities. Revise manual handling exercises to include body stretches. Requiring risk assessment (including ergonomics) in manual handling work. Give a warning to the supervisor.	Implemented in 2021. Implemented in 2021. Implemented in 2021. Implemented in 2021 and risk assessment is included in the 2023 B2B module. Conducted in 2021.
8	2022 (RWDC). A contractor worker injured his hand during work preparation.	Exceptional Violations. Safe access is available, but workers select other unsafe paths. The worker takes shortcuts by wearing lightweight gloves rather than impact-resistant gloves to handle manual work on heavy equipment.	Adverse Mental States. The worker has a bad attitude towards safety. The worker did not report/stop work when he slipped on manual handling & his colleague also slipped while working. The worker also did not immediately report the accident to the finger until the worker was unable to treat the injury himself and then reported it to the doctor/medic.	Inadequate Supervision. No audit/verification was carried out on this worker contractor. Closed-circuit television (CCTV) cameras for work monitoring are blocked by equipment limiting the use. No induction was carried out (this was the first time going offshore)	Resource Management. The behavior of workers is not monitored/selected before being sent offshore.	Conduct comprehensive induction of new workers. Reprimand contractors and require verification/audits of all workers and not send those with poor safety habits. Ensure CCTV is placed in strategic places that are not obstructed for effective work locations and	**Already.** Induction for contractors before work is strengthened (instilling expectations from the company in relation to HSE including stop work authority), conducting interviews (with supervisors and key persons from contractors) to ensure contractor competency including behavior

No	Year & Type of Accident	Unsafe Acts	Precondition for Unsafe Acts	Unsafe Supervision	Organizational Influence	Recommended Occupational Health and Safety (OHS) interventions are based on findings in HFACS stages	Is it included in PT X Occupational Health and Safety (OHS) interventions in 2023?
						activities monitoring.	assessments before leaving offshore. Implemented in 2022.
							Implemented in 2022.
9	2022 (RDWC) A contractor worker injured the hand while working.	Skill-based errors. The worker grabbed the fan belt accidentally causing the belt to move inward and get the fingers caught.	Physical Environment. The workplace is cramped and dangerous.	Failure to correct problems. Cramped and potentially dangerous workspaces have been known since the platform was operational, but no action has been taken to make the work site safer. The supervisor is complacent about this.	Resource Management. No higher equipment/work platforms are available to avoid technicians working inside the cooling fan box. There is also no separate access frame for independent access to each workplace (cooling fan box).	Reprimand the contractor to be more careful in their work and ensure that only competent workers can be sent offshore Modify equipment/platforms for workers to work outside the cooling fan box. Provides independent access to each workplace (cooling fan box). Occupational Health and Safety (OHS) program to minimize complacency (lack of attention from supervisors to unsafe work locations).	Implemented in 2022. Implemented in 2022. **Already.** Complacency is included in the B2B program.
10	2022 (LWDC). Two contractor workers were exposed to hydrochloric acid when transferring hydrochloric acid.	Decision errors. The workers removed the discharge hose on Pump #2 even though it was still pressurized. Exceptional Violations. When opening the hose at the damaged acid pump, workers did not use	Adverse Mental States. It could be caused by workers (4 people) who were tired from working since 6 am (and the accident occurred around 12 pm) which might disrupt the circadian cycle. Or it could also be caused by pursuing a target that the next day the work must be finished. Technological Environment.	Supervisory Violations The supervisor of the contractor worked to repair the damaged acid pump without PPE. The supervisor also agreed that testing the pressure on the hose should use a non-hazardous liquid	Resource Management. Lack of human resources of the contractor in terms of the number of competent personnel, causes individuals to work excessive hours, on the day of the incident, and this may cause a lack of concentration due to fatigue. Lack of competence of workers of the contractor in carrying out acid pump repair work.	Reprimand the contractor and require them to carry out verification/audits of all their workers (competence and adequacy of numbers, work procedures) and not send workers with poor safety habits. Conduct comprehensive induction of new workers.	Implemented in 2022. **Already.** Induction for contractors before work is strengthened (instilling expectations from the Company in relation to

No	Year & Type of Accident	Unsafe Acts	Precondition for Unsafe Acts	Unsafe Supervision	Organizational Influence	Recommended Occupational Health and Safety (OHS) interventions are based on findings in HFACS stages	Is it included in PT X Occupational Health and Safety (OHS) interventions in 2023?
		appropriate PPE. Testing the pressure on the hose should use a non-hazardous liquid according to the procedure, but actually, there is hydrochloric acid in the hose. The only work permits authorized are for hydrochloric acid transfer operations and not for the repair of damaged acid pumps.	There is no pressure gauge installed on the acid pump that can indicate excess pressure rise when the pump is operating.	according to the procedure. Planned Inappropriate Operations. The supervisor of the contractor agreed to use a replacement hose to pump the acid without verification from an independent party. Inadequate Supervision. The Area Authority (PT X) did not stop work and assessed the situation when it saw the acid pump being repaired.	Bad behavior from workers and supervisors: Working without appropriate PPE, testing hose pressure using acid, and not a single work member to stop it (stop work authority). Organizational Process. The contractor's procedures were not specific regarding what type of hose should be used for acid pumping. There is also no guidance on how hoses should be tested, ideally in scenarios where no pressure is required, and the fluid used is not hazardous.	Ensure 24-hour supervision from PT X Implement fatigue management. Create a quality management system at PT X	HSE including stop work authority), conducting interviews (with supervisors and key persons) to ensure contractor competency including behavior assessment before leaving offshore. Partially done. Part of the intervention in 2023 (Supervisory). Documents explaining the minimum supervisory requirements for offshore activities are still being created. **Already**. Part of the intervention in 2023 (fatigue management). Ongoing.

Table 2. Distribution of HFACS factors on accidents at PT X

HFACS stages	Subcategory	Total cases identified per factor	Percentage
Unsafe Acts	decision errors	4	30,8%
	skill-based errors	2	15,4%
	perceptual errors	2	15,4%
	routine violations	2	15,4%

	exceptional violations	3	23,1%
	physical environment	2	16,7%
	tools/technological	3	25,0%
	adverse mental state	6	50,0%
Precondition for Unsafe Acts	adverse physiological state	1	8,3%
	physical/mental limitations	0	-
	communication, coordination, & planning	0	-
	fitness for duty	0	-
	inadequate supervision	3	30,0%
Unsafe Supervision	planned inappropriate operations	1	10,0%
	failed to correct the problem	4	40,0%
	supervisory violations	2	20,0%
	resource management	7	50,0%
Organizational Influences	organizational climate	1	7,1%
	organizational process	6	42,9%

DISCUSSION

As shown in Table 2, two factors equally contributed the most to causing accidents, namely resource management and adverse mental state, both at 50%. The second and third factors were organizational process (42.9%) and failed to correct the problem (40%) respectively. In the stage of Unsafe Acts, decision error predominated (30.8%) while in Precondition for Unsafe Acts, the greatest contributing factor was adverse mental state (50%). Unsafe Supervision was dominated by failure to correct the problem (40%) and Organizational Influence was mostly affected by resource management (50%) and organizational process (42.9%).

The disparity between this study and Nwankwo [12] can be attributed to variations in the number of accident cases (10 vs 184 cases), different demographics (1 company vs global scale), as well as differing safety practices, safety cultures, and Occupational Health and Safety Management Systems (SMK3). An effective SMK3 covers control functions over accidents, losses, hazards, and risks [11]. However, certain factors causing accidents in Nwankwo [12], including organizational process (86% vs 42.9%), technological (77% vs 25%), and organizational climate (68% vs 7.1%) were not consistent with this study. The results were not similar to those of a previous study by Khodijah [10]. The disparity could be due to slight differences in the company (oil and gas activities on platforms and ships including drilling vs. drilling activities only), duration of data collection (5 vs. 1 year), and the amount of data (10 vs. 3 datasets).

Based on the information provided, accidents prevention programs at PT X can be prioritized on the four factors namely resource management, adverse mental state, organizational process, and failed to correct problems. Furthermore, secondary priority may be given to other significant factors, which are decision error (30.8%), and inadequate supervision (30%).

OHS program for accident reduction at PT X in 2023 mostly focused on all stages outlined in HFACS without considering priorities (Table 1). To enhance effectiveness, it is recommended to take additional actions addressing latent conditions including preconditions for unsafe acts, unsafe supervision, and organizational influences, which trigger other accidents [14]. Therefore, the following additional recommendations are proposed:

In Table 1, referring to accident number 1, periodic management visits to support vessels are recommended to facilitate the sharing of OHS information and promote leadership engagement. Referring to accident number 3, an additional recommendation is proposed to include guidance on the use of prescription safety glasses for first-time users in the worker induction program before moving offshore. An additional recommendation for accident number 4 is to improve work procedures requiring all tasks to pass through Job Risk Analysis (JRA) or establish standardized processes for determining low risk.

CONCLUSION

In conclusion, PT X successfully reduced the number of accidents in 2023 by implementing prevention measures. These accident prevention measures were generally consistent with the analysis results using HFACS,

which generated relatively comprehensive recommendations by focusing on unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences. Several proposed recommendations from the analysis of latent conditions in HFACS were expected to further enhance OHS performance at PT X.

This qualitative study was limited to only discussing OHS intervention programs for recordable injury incidents between 2018 and 2022. The analysis was not expanded to include accidents classified as First Aid Cases (FAC) and Near Misses (NM), nor those leading to losses including property damage, or environmental impacts, which could potentially provide a broader profile of latent conditions and more comprehensive recommendations.

SUGGESTION

HFACS is highly suitable for analyzing human factors-based workplace accidents. This study suggests conducting similar investigations related to human factors using HFACS to obtain comprehensive results, which include recommendations for addressing both unsafe acts and latent conditions. The recommendations from the analysis can be used by companies and government entities as input for designing effective OHS programs, particularly aimed at minimizing workplace accidents.

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