ANALYSIS OF WORK ACCIDENTS IN DRILLING AND WELL REWORK ACTIVITIES IN PT BCY'S RIG USING CONCEPTS HUMAN FACTOR ANALYSIS

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Abstract
Between 2019 and 2024, PT BCY recorded 26 reportable workplace incidents, including serious injuries and fatalities. This study aims to analyze the contributing factors to these incidents using the Human Factors Analysis and Classification System (HFACS). Employing a descriptive method, the study utilized 26 accident and near-miss reports. Incidents were categorized into four HFACS levels: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences. The analysis identified 38 cases involving organizational influences, 36 involving unsafe supervision, 43 involving preconditions for unsafe acts, and 34 involving unsafe acts. Preconditions for unsafe acts were the most frequently identified contributing factor.
Keywords: HFACS, occupational Health and Safety, work accidents.

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INTRODUCTION

The Oil and Gas industry has a strategic role in national development, both as a source of energy (1), fuel and state revenue also creates *a multiplier effect* that is able to move the economy where oil and gas activities are located (2). Although the global oil and gas market has been affected by falling crude oil prices, Indonesia's oil and gas sector remains relatively stable and holds potential for further development, due to many unexplored and untapped reserves. However, the industry is fraught with significant risks such as accidents, fires, explosions, occupational illnesses, and environmental pollution. Neglecting safety in oil and gas operations can lead to severe economic losses, injuries, and fatalities. (3,4).

In 2023, the national oil and gas lifting targets were 660,000 barrels of crude oil per day (BOPD) and 1,100,000 barrels of oil equivalent per day (BOEPD) for natural gas. However, by the end of December 2023, actual production reached only 605,500 BOPD for oil and 964,000 BOEPD for gas (5). To address this shortfall, the Government along with oil and gas companies accelerated the drilling of new wells and initiated workovers and well interventions in existing wells. It is recorded that until August 31, 2024, development wells have been drilled reaching 545 wells and exploration wells of 25 wells. As of August 31, 2024, there were 545 development wells and 25 exploration wells drilled. Despite updated regulations and improved safety standards, accidents still occur. Data from the Directorate General of Oil and Gas show that in 2016 there were 117 incidents, decreasing to 86 in 2017, rising again to 149 in 2018, and then decreasing to 56 by 2022.

PT BCY is a company engaged in support services for drilling operations and well rework which mainly operating around Riau or the Rokan Working Area. In 2007, starting with the formation of 2 (two) *workover rigs* in the Duri Area, currently PT BCY has 15 (fifteen) rig units of various specifications. The company's intensive drilling and well rework programs

involve a large workforce and carry high safety risks, underscoring the need for effective safety management systems based on human performance and integrated with existing organizational management systems.

From the PT BCY's Safety Performance report throughout 2019-2024, there were 26 cases of *recordable incidents*, including cases resulting in serious injuries and *fatalities*. There were accidents fluctuation at PT. BCY throughout 2019 – 2024. Especially after 2021, following the COVID-19 pandemic recovery, the massive drilling program aimed to achieve the target number of well work has caused the company to focus only on essential things for the maintenance of safety and drilling rig equipment, massive recruitment of labor has also resulted in an increase in the number of working hours per day. Along with this, the number of work accidents at PT BCY has also increased. One incident in 2024 resulted in four workers sustaining burn injuries. The high number of work accidents causes work performance to decline (6). These trends indicate a need to investigate the underlying causes of these incidents using the HFACS approach.

METHODS

This study employed a descriptive approach using secondary data from 26 reports of workplace accidents and near-miss incidents at PT BCY between 2019 and 2024. The data were analyzed using the Human Factors Analysis and Classification System (HFACS) Framework, which classifies root causes into four layer which are organizational influences, unsafe supervision, preconditions for unsafe acts, and unsafe acts.

RESULTS

Data on work accidents that occurred at PT. BCY from the period 2019-2024, is recapitulated to see the parameters of the work accidents, the date of the work accident, the classification of work accidents and the types of work accidents. The following is accident data based on the year of the incident, which can be seen in Figure 1.

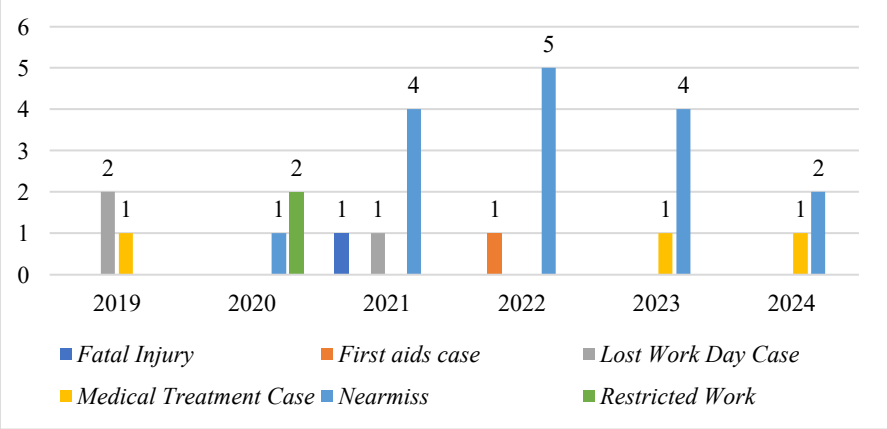

Figure 1. Work accident data

The following is the frequency of the distribution of factors that cause work accidents in 26 incidents from 2019 to 2024, which can be seen in Table 1.

Table 1. Factors that cause work accidents

No.	HFACS Factor	HFACS Sub Factors	Number of cases	Percentage per factor	Causes of Occurrence
1	*Organizational Influences*	*Resources Management*	23	61%	The standard procedures applied are inadequate, Lack of training programs for workers in their field of work
		Organization Culture	11	29%	Lack of awareness of the safety regulations in doing a job, lack of a good communication between fellow workers
		Organizational Process	4	11%	Absence of SOPs regarding the work carried out
2	*Unsafe Leadership*	*Inadequate Leadership*	18	50%	The supervisor does not supervise directly, the supervisor does not ensure that the work carried out is in accordance with the SOP
		Planned Inappropriate Operations	12	33%	Lack of manpower, not ensuring the work area is in safe condition, inappropriate work design
		Failed to correct problem	5	14%	Ignoring safety indicators, failed to learn from the same mistake
		Leadership Violations	1	3%	Supervisor grants operating clearance without ensuring safe conditions
3	*Preconditions for Unsafe Act*	*Environmental Factors*	19	44%	Unsupported work fields, lack of lighting due to night work
		Condition of Operators	12	28%	The condition of workers who experience work fatigue due to night working hours, lack of awareness of potential dangers
		Personnel Factors	12	28%	Communication that is not well established, workers do not know the SOPs and JSA to support their work
4	*Unsafe Acts*	*Errors*	22	65%	The work is done in a hurry, not paying attention to the dangerous conditions
		Violations	12	35%	Violating work safety rules and SOPs

DISCUSSION

Distribution of Work Accident Data

Referring to Figure 1, the number of work accidents and *nearmisses* that occurred at PT. BCY during 2019 to 2024 as many as 26 incidents. Where 15 out of 26 incidents were nearmiss events . One case of work accident is *a fatality injury* that causes the victim to die, 3 work accidents result in *lost work day cases*, 1 case of work accidents is *a First AIDS case*, 3 work accidents require *medical treatment cases*, and 2 work accidents are *restricted work.*

The trend of work accidents that occurred at PT BCY from 2019 to 2024 has increased and decreased or can be said to fluctuate. But the incidence of work accidents has increased significantly from 2020 to 2021. Where the incidence of work accidents in 2019 to 2020 was stable at 1 incident, but increased in 2021 with 6 incidents of work accidents.

When viewed from the type of work accident, the type of work accident due to being hit by an object is a recurring occurrence. It can be seen from 9 work accidents, 5 of which were caused by being hit by workpieces. This can be caused by several factors that affect it. But when viewed from the time of the incident, the work accident occurred during work carried out at night. Where work carried out at night reduces the visibility of workers, poor lighting

conditions for work and reduces workers' vigilance due to the condition of workers who experience work fatigue.

Given that the oil and gas industry operates 24 hours a day, there are times when workers do work that requires a high level of concentration and physicality, as it is done at night. Work done at night increases the fatigue and alertness of workers. This is in line with research conducted by Rezki and Baiduri (7), stating that the shift work system decreases worker concentration and increases the level of work fatigue felt by oil and gas workers. As evidenced by research conducted by Mcnamara and Smith (8), it is stated that the schedules of oil and gas workers carried out during the night shift increase work fatigue and ultimately increase the risk of work accidents.

Organization Influence Factors That Contribute to the Occurrence of Work Accidents

It was identified that 38 cases out of 302 cases were caused by organizational influence factors, with details of 61% due to management issues, 29% due to organizational influence and 11% due to organizational processes. Described from the large percentage of organizational influence factors, the resource management sub-factor is the largest sub-factor identified, with a percentage of 58%. Meanwhile, the smallest sub-factor of cases identified was the Organizational Process sub-factor, with a percentage of 12%. Based on the results of the analysis of the sub-factors of resource management, it causes fatality injuries, lost day work, restricted work, medical treatment cases, first aid cases and nearmiss. Sub-factors of organization culture cause fatality injuries, lost day work, restricted work, medical treatment cases and nearmiss. Sub-factors of the organizational process cause fatality injuries, lost day work, restricted work and nearmiss.

Of the 26 work accidents and near-accident incidents, the sub-factor of resource management was found to be mostly due to the standard procedures applied to be inadequate for the work being done and the lack of training programs for workers in their field of work. If the conditions where the standard operating procedures are inadequate for the work being done, it causes a lack of risk mitigation that arises and increases the potential for accidents. This is in line with research that has been conducted by Kirana et al (9) and Karel et al (10) in the study revealed that the application of standard operating procedures is related to the risk of work accidents. Given that the procedures are updated in accordance with technological developments and equipment carried out when doing the work. With the development of technology, it raises the risk of danger, so existing safety standards are no longer relevant to be implemented. In addition, the lack of training programs leads to an increased risk of work accidents. Considering that the provision of training programs is a step that organizations can do in improving the ability and knowledge of workers about the risk of danger so that it can reduce the rate of work accidents. This is in line with research that has been conducted by Kirana et al (9) and Karel et al (10), which reveals that training programs are related to reducing the number of work accidents.

The cases identified in the Organization Culture subchapter are caused by a lack of awareness of the importance of occupational safety and health when doing a job and the lack of communication with fellow workers. The importance of workers' awareness of occupational safety and health when doing a job can have an impact on reducing the rate of work accidents. Because workers who have motivation in them will comply with the rules and procedures of

occupational safety and health, and workers are more responsive to potential dangers. In line with the research that has been conducted by Asilah and Yuantari, it is revealed that worker motivation is related to the incidence of work accidents (11). In addition, the establishment of good communication has an effect on reducing the rate of work accidents, because the oil and gas industry which has a high risk of work accidents due to many potential hazards, good communication can be one of the good solutions in order to reduce the likelihood of work accidents. Similar research has been conducted by Febriana et al those who conclude that the implementation of good communication has an effect on reducing the risk of work accidents (12).

The cases identified in the organizational process subchapter are caused by the absence of standard operating procedures as a reference in doing a job. Especially for oil and gas workers with much greater potential for danger, with the existence of standard operating procedures for workers can minimize risks by avoiding unnecessary work. This is in line with research that has been conducted by Pangestu Klik atau ketuk di sini untuk memasukkan teks.revealing that the application of standard operating procedures is related to accident incidents (13). As evidenced by research that has been conducted by Karel et al, in the study it is concluded that work that applies standard operating procedures to each job, has an effect on reducing the incidence rate of work accidents (10).

Unsafe Supervision Factors That Contribute to the Occurrence of Work Accidents

It was identified that 36 cases out of 302 cases were caused by unsafe leadership factors, with details of 50% caused by Inadequate Leadership, 33% caused by Planned Inappropriate Operations, 11% caused by Failed to correct problems and 3% caused by Leadership Violations. The Inadequate Leadership is the sub-factor that has the highest percentage of cases, which is 50%, while the leadership violations sub-factor is the sub-factor with the lowest percentage of cases, which is 3%. The results of the Human Factors Analysis and Classification System (HFACS) sub-factor inadequate leadership are caused by the absence of direct supervision by supervisors when performing a job and the supervisor does not ensure that the work done is in accordance with standard operating procedures. Supervisors who actively supervise a job tend to ensure workers follow work safety rules.

If direct supervision were done regularly, workers are reluctant to violate rules that can increase the risk of work accidents. Supervision from supervisors needs to be carried out by oil and gas workers when they want to do a job. Considering that the risk of hazardous sources in oil and gas drilling work is higher than other jobs. So that direct supervision by supervisors is expected to reduce the rate of work accidents. This is in line with the research that has been conducted by Angriai et al the study stating that supervision from superiors affects the occurrence of work accidents (14). In addition, it is evidenced by research that has been carried out by Fadhli and Sari, which states that supervision carried out by the Department of K3 has proven to be effective in reducing the occurrence of work accidents (15).

The results of the identification of the cause in the sub-factor planned inappropriate operations lack of the number of workers, do not ensure that the work area is in safe conditions and the work design is not suitable. At a time when the number of workers is not in accordance with the work to be done, increasing the workload resulting in an increased risk of work accidents. In addition, supervision carried out by supervisors plays an important role in

reducing the occurrence of work accidents. With this supervision, it is ensured that the workforce follows occupational safety procedures and rules, and can detect the risk of danger before a work accident incident occurs. If supervision is not carried out, workers are less likely to have self-control to work safely, increasing the risk of workplace accidents. The results of the research are in line with the research that has been carried out by Angriai, et al revealing that direct supervision from supervisors is related to a reduction in the occurrence of work accidents (14). The design of the work is designed before a work is done.

Work design includes workload management as well as ergonomic layouts to perform a job. If the conditions are overloaded, the work layout is not ergonomic and the lack of clear work safety procedures can increase the risk of work accidents. This is inversely proportional if a job is well designed, can reduce unnecessary work, reduce work fatigue because the workload is given equally to all workers and minimize the risk of harm caused. This is in line with research that has been conducted by Khamid et al mentioning that work that is well designed and planned can reduce the likelihood of work accidents (16). Similar research has been conducted by Sujasmin et al those who say that a workload that does not burden workers has an effect on reducing the likelihood of work accidents (17) .

The results of the identification of the failed to correct problem sub-factor are caused by workers who ignore safety indicators and do not learn from the same case so that repeated incidents occur. A hazard warning system can increase worker awareness if there is a potential hazard and provide guidance on how to avoid these conditions to reduce the occurrence of work accidents. Especially in the morning of oil and gas drilling workers. Where workers are faced with much greater danger conditions compared to other types of work. Proactive steps are more suitable to be implemented, if you wait until an accident occurs, it causes many negative impacts, not only production failures, but can cause casualties. In line with the research that has been carried out by Putra, which states that preventive measures at the source of danger have an effect on the occurrence of work accidents (18).

Meanwhile, the cause of cases in the leadership violations sub-factor is mostly caused by supervisors giving operating permits without ensuring workplace conditions. Oil and gas jobs with various sources of hazards require various work permits to minimize the possibility of work accidents. But in practice, it is still found that the granting of work permits is only limited to work conditions, not as a control of workers in doing work. Many work permits are granted that do not meet the standards applied, in the hope that the work will be completed quickly. In line with the research that has been carried out by Aisah and Susilawati the granting of safe work permits, it has an effect on reducing the occurrence of work accidents (19). As evidenced by the research that has been carried out by Sanditya et al, the study concluded that the granting of work permits issued by leaders is considered effective as a preventive measure to prevent the occurrence of work accidents (20).

Precondition to Unsafe Act Factors That Contribute to the Occurrence of Work Accidents

It was identified that 43 cases out of 302 cases were caused by precondition to unsafe act factors, with details of 44% due to environmental factors, 28% due to condition of operators and 28% due to Personnel Factors. The environmental factors sub-factor is the sub-factor that has the highest percentage of cases, which is 44%, while the personnel sub-factor is the sub-

factor with the lowest percentage of cases, which is 28%. The results of the identification of sub-factors of environmental factors are caused by the work field that does not support work, lack of lighting due to work at night. The oil and gas drilling work area is designed not to do work, but the work area is designed as well as possible so that workers can do work in the area. The danger that often threatens is unpredictable weather, aggravated by the work area that is outdoors, if in the rainy season it increases unsafe conditions because the work area becomes slippery and watery.

This is in line with research that has been conducted by Scott et al those who stated that slippery work area conditions can increase the risk of work accidents (21). It is evidenced by research that has been conducted by Lumadja, et al those who reveal that work locations that are not safe to do work are related to work accidents (22). In general, many of these conditions are found in slippery work areas, differences in ground surface height, strong winds, which can increase the risk of work accidents. In addition, oil and gas drilling work is carried out 24 hours a day, which if done at night increases the risk of hazards that will arise. The lack of lighting is an obstacle because workers are less aware of the dangers that exist as a result of short visibility, in contrast to work done during the day. In line with the research that has been conducted by Adi who conclude that the work environment is one of the factors that affect the occurrence of work accidents, especially lighting problems (23). It is evidenced by research conducted by Arifuddin, et al concluding that an uncomfortable work environment increases the risk of work accidents (24). Supported by research that has been conducted by Supriyanto, et al who reveal that the intensity of lighting in the work area is related to the occurrence of work accident cases (25).

The results of the identification of the Condition of Operators sub-factor with the result that many workers complained of work fatigue felt by the workers. Oil and natural gas drilling work is carried out for 24 hours with a shifting work system. This condition increases the risk of workers experiencing work fatigue. This disrupts the sicardial rhythm, where the worker's body realizes that during the day it is active and at night it is the time for the worker's body to recover after a day of work. If this condition continues to be left unchecked, it will increase work fatigue and also increase the risk of work accidents due to the level of occupational vigilance, the risk of danger will decrease. In line with the research that has been carried out by Basalamah et al (26) the study concluded that work fatigue has an effect on the incidence of work accidents. Workers who feel high work fatigue increase the risk of work accidents. It is proven by research conducted by Arifatunnahriyah, et al, that found the good management of factors that can affect work fatigue can reduce the risk of work accidents (27).

Unsafe Act Factors That Contribute to the Occurrence of Work Accidents

Identified as many as 34 cases out of 302 cases were caused by unsafe act factors, with details of 65% caused by errors and 35% caused by violations. The error sub-factor is the sub-factor that has the highest percentage of cases, which is 65%, while the violations sub-factor is the sub-factor with the lowest percentage of cases, which is 35%. Based on the results of identification of the error sub-factor, most of it is caused by work that is carried out in haste and does not pay attention to the dangerous conditions. Work that is done in a hurry tends to pay attention to quantity rather than quality. Workers want work done quickly and tend to use shortcuts to get it done. On the other hand, work that is done in a hurry can occur due to time

pressure. This condition causes negligence, poor job decision-making and often violates work safety rules.

This needs to be avoided, oil and gas workers are faced with difficult field work, if the work is done in a hurry, it can increase the risk of work accidents. This is in line with research that has been conducted by Wahyuni, et al which states that wrong decision-making can increase the occurrence of work accidents (28). It is evidenced by research that has been conducted by Asilah and Yuantari, who found that work accidents occur, one of which is caused by work done not in accordance with work safety rules and work done without paying attention to the quality of work (11).

The results of the identification of sub-factor violations were caused by workers violating safety rules and standard operating procedures. Violations of safety guidelines are ignored have the potential to increase the risk of work accidents. Violations can be caused by several reasons, such as lack of workers' awareness of the importance of working by paying attention to work safety rules, excessive work pressure and weak supervision. This is in line with research that has been conducted by Sulistyaningtyas, stating that violations of work safety rules and standard operating procedures are one of the factors that affect work accidents (29). It is evidenced by research that has been carried out, that the implementation of occupational safety rules has an effect on reducing the number of work accidents (30).

CONCLUSIONS AND RECOMMENDATIONS

Sub-factors in organizational influence factors that affect the occurrence of work accidents that occur at PT BCY in 2019 to 2024 are resource management 61%, organizational culture 29% and organizational process 11%. Sub-factors in unsafe leadership factors that affect the occurrence of work accidents that occur at PT BCY in 2019 to 2024 are inadequate leadership 50%, planned inappropriate operations 33%, failed to correct problem 14% and leadership violations 3%. Sub-factors in the precondition for unsafe acts that affect the occurrence of work accidents that occur at PT BCY from 2019 to 2024 are environmental factors 44%, condition of operators 28%, and personnel factors 28%. Sub-factors in unsafe acts that affect the occurrence of work accidents that occur at PT BCY from 2019 to 2024 are 65% errors and 35% violations. Based on the results of the Human Factors Analysis and Classification System (HFACS) analysis of all work accidents and near accidents, the preconditions for unsafe act factor was the most identified factor.

Based on the conclusions of the research, suggestions could be given as follows: (1) strengthen the safety refreshment program regarding standard operational procedures for workers to ensure their level of competence and behavioral aspects to always comply with occupational safety rules; (2) regularly update standard operating procedures and create procedures or supplement existing procedures based on the findings of HFACS analysis and review any areas that do not have procedures; and conduct engineering control reviews to ensure the work environment is safe to do work.

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