

Occupational Health and Safety Risk Assessment Application in Oil Refinery Using Hazard Identification, Risk Assessment and Risk Control (HIRARC)

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Abstract - This research aims to evaluate occupational safety and health (OHS) risks in the oil refinery unit of PT XYZ using the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method. This method involves three main stages: hazard identification, risk assessment, and risk control. The research was conducted descriptively and qualitatively through field observations, interviews, and the use of the HIRARC checklist. The identification results show that several work areas, such as the evaporator, separator, and stabilizer, have a Very High risk level due to extreme pressure and temperature, gas leakage, and the potential for explosion and fire. The risk assessment was conducted by considering the likelihood and consequences of each hazard. The risk control strategies analyzed include technical, administrative, and the use of personal protective equipment (PPE). However, most controls are still dominated by administrative approaches, while technical controls such as gas detection systems and shutdown automation have not been implemented optimally. The implementation of HIRARC has proven to be effective in systematically identifying and controlling risks and contributing to a safer, healthier, and more productive work environment in the oil and gas industry.

Keywords – Accident Risk, HIRARC, Occupational safety, Refinery unit

I. INTRODUCTION

The oil and gas industry is a strategic sector that not only supports the national economy but also holds high potential for workplace hazards (Hidayatullah et al., 2024). Operational activities such as chemical processing, heavy equipment operation, and extreme temperature and pressure control make this sector vulnerable

to various types of workplace accidents (Nurjannah et al., 2025). Therefore, the systematic implementation of Occupational Safety and Health (OHS) is an urgent need to ensure the continuity of operations and the protection of the workforce.

PT XYZ is a company whose main task is to process crude oil from drilling into several ready-to-use products. The products produced include residue, diesel, and Pertasol. The crude oil production process in this company involves a heating stage, or what is known as atmospheric distillation. The Crude Distilling Atmospheric Unit (CDU) is one of the main units in crude oil processing at the refinery, which requires in-depth risk analysis due to the potential hazards that exist (Purwanto et al., 2024).

Oil refineries play an important role in supporting national energy security, especially in the midst of increasing fuel demand due to population and economic growth (Rahmansyah & Anggitasari, 2024). However, work in refinery units carries high OHS-related risks, given the complexity of operations involving high-tech equipment, hazardous chemicals, and extreme working conditions (Fadolly, 2021).

Common risks faced in an oil plant work environment include oil and gas leaks that can potentially cause fires, exposure to hazardous chemicals, high temperatures that can trigger burns, and machine noise that threatens workers' hearing health (Willy Afredo & Tarigan, 2021). In addition, high pressure in pipes and tanks is also a source of danger that needs to be mitigated. Such situations require special attention from the Industrial Hygiene unit to recommend corrective actions if hazardous conditions are found. This approach is especially important to avoid ergonomic hazards through effective job or work site design that is appropriate to the physical environment and task characteristics

(Attaqwa et al., 2021).

Unfortunately, there are still many challenges faced in implementing the OHS system. Low labor awareness of the importance of using personal protective equipment (PPE), lack of continuous OHS training, and weak supervision of equipment maintenance are the main causes of the high number of work accidents in the oil and gas industry (Muhammad & Susilowati, 2021). Evaluation and improvement of the OHS system as a whole is important, and one approach that can be applied effectively is the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method (Umami et al., 2021).

Several studies on the application of HIRARC have proven effective in various sectors. For example, research conducted by Vikaliana & Melani (2024) shows the effectiveness of HIRARC in oil and gas warehouses in reducing logistics operational risks. Added with research conducted by Dewantari et al. (2022) shows the effectiveness of the HIRARC method in the construction sector, especially in the construction of the Business Center building at University Y. This method is proven to be able to identify potential hazards, assess risk levels, and establish appropriate controls to prevent work accidents (Allo, 2025).

This research aims to apply the HIRARC method to identify potential hazards in the oil and gas company's refinery unit, assess the level of risk of work accidents based on influential factors, and determine effective prevention efforts to minimize these risks. The scope of the research is focused on the work area of the Oil and Gas Company's refinery unit, which is at high risk of mechanical, chemical, and thermal hazards.

The benefits of this research are to provide scientific and practical contributions to the management of OHS in the oil and gas work environment, especially in oil and gas companies. In addition, this research is also expected to be a reference for educational institutions and job training in improving the quality of safety management systems in accordance with industry standards and applicable regulations.

II. THEORY REVIEW

A. Occupational Safety and Health

According to Surya & Ririh (2021), Occupational Safety and Health (K3) is an effort to create a work environment that is safe, comfortable, and free from the risk of accidents while working. In general, K3 aims to protect workers from various hazards that can threaten physical, mental, and emotional safety, as well as maintain the security of the company, community, and the surrounding environment. The implementation of OHS is also expected to create a sense of comfort and security for workers in carrying out their duties. Occupational safety and health play an important role in reducing the likelihood of occupational accidents in the workplace. In addition to direct factors such as exposure to physical and chemical hazards, the risk of accidents can also be influenced by operational planning aspects such as unbalanced workload distribution. Research by Pulansari et al. (2020) shows that the imbalance of production trajectories can create *bottlenecks* that have an impact on increasing work pressure at certain points, which in turn can increase the chances of work accident incidents.

B. OHS Management System

According to Surya & Ririh (2021) the OHS management system is a process that regulates all matters related to occupational safety and health within the company. The OHS management system acts as a system that manages various aspects of OHS, from planning, division of responsibilities, implementation, to managing the resources needed by the company to carry out occupational safety and health policies. The main objective of the OHS management system is to improve OHS protection in a targeted manner, prevent and reduce the risk of work accidents, and create a safe and comfortable working environment for workers.

C. HIRARC

According to Willy Afredo & Tarigan (2021), explains that HIRARC is a method used to minimize or prevent work accidents. HIRARC aims to identify

hazards that may occur and to avoid work accidents. This method has several stages: the first stage is identifying hazards, the second is risk assessment, and the third is risk control.

D. Risk Assessment

According to Willy Afredo & Tarigan (2021), risk is the possibility of loss or even profit as a result of a certain event or action. Risk can be interpreted as a measure of potential hazards that considers how much loss may occur and how much chance the event has, according to the AS/NZS 4360:

2004 standard, risk is defined as the chance of an event that can have an impact, either directly or indirectly, on an object or system. Risk is usually calculated or assessed based on two main components, namely likelihood (the possibility of an event occurring) and consequence the impact or result of the event). The greater the chance of an event occurring and the more severe the impact, the higher the risk. The following description of risk assessment is presented in tabular form.

Table 1 Likelihood Scale

Level	Description	Description
1	Rare	Almost never happens
2	Unlikely	Rarely occurs
3	Possible	May occur occasionally
4	Likely	Frequent occurrence
5	Almost Certain	It may occur at any time

Table 2 Severity Scale

Level	Description	Detail
1	Negligible	No injury, small financial loss
2	Minor	Minor injury, medical treatment, and low financial loss
3	Moderate	Moderate injury, medical treatment required, major financial loss
4	Major	Severe injuries, heavy losses, up to 2 deaths
5	Catastrophic	More than two people died, and the impact was far-reaching, halting all activities.

Table 3
Risk Level Scale

Level of likelihood	Security Level				
	1	2	3	4	5
1	L	L	M	M	H
2	L	L	M	H	H
3	L	M	M	H	VH
4	M	M	H	H	VH
5	M	H	H	VH	VH

Table 4
Risk Level Category

Simbol	Level	Action
L	Low Risk	Monitoring to ensure control measures are working properly
M	Moderate Risk	Requires an assessment to determine if control measures are adequate
H	High Risk	Management's attention is required, and corrective action is required.
VH	Very High	Immediate corrective action is required

III. METHODS

This research uses a qualitative descriptive approach that aims to describe systematically, factually, and accurately the facts that occur in the field related to potential hazards and

occupational safety and health risks in the refinery unit. This research also utilizes direct observation methods to obtain data related to hazard identification and occupational risk control, especially in the crude oil processing

process. In addition to qualitative data, this research also utilizes quantitative data such as historical accident records and log data from monitoring instruments (e.g., temperature and pressure records). This is to support more objective analysis in the hazard risk assessment process.

Data in this study was collected using three main techniques, namely:

1. Field Observation

Direct observations were made in various work units within the refinery, such as pumping units, furnaces, separators, and storage tanks, to identify potential hazards and working conditions.

2. Interviews

Unstructured interviews were conducted with field supervisors and operators to obtain in-depth information related to work procedures, potential accidents, and preventive measures implemented.

4. HIRARC Checklist

Used to record potential hazards based on specific work activities and assist in assessing the level of risk based on the parameters of likelihood and consequence.

The data collection stages carried out by the research in the form of a flowchart are as follows:

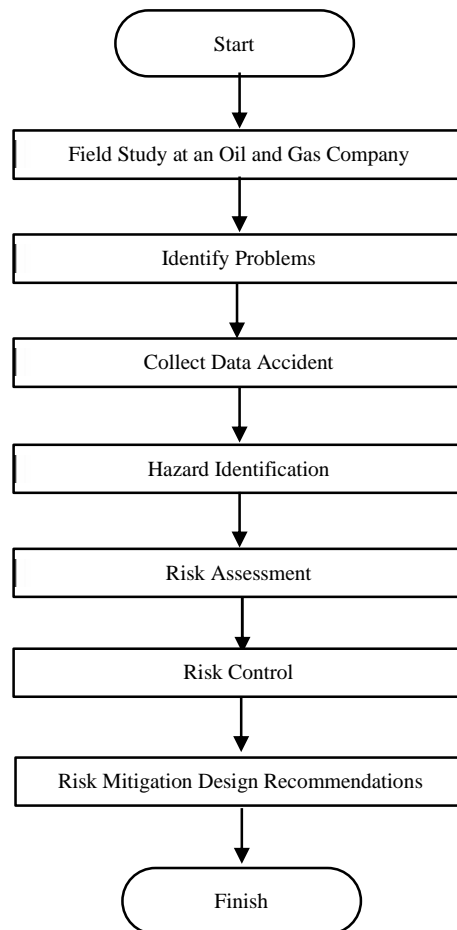


Figure 1: Flowchart of data collection work scheme

The analysis in this study was carried out using the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method with the following stages:

1. Hazard Identification

Identify all potential hazards at the

worksite based on the work area and activity, such as exposure to high temperature, high pressure, gas leakage, and noise hazards.

2. Risk Assessment

Each potential hazard that has been identified is then assessed for its risk

level by considering two main parameters, namely likelihood (the possibility of the event occurring) and consequence (the impact or result of the event).

3. Risk Control

Determine appropriate control measures based on the level of risk, with reference to the risk control hierarchy, namely: elimination, substitution, engineering control, administrative control, and the use of Personal Protective Equipment (PPE).

IV. RESULT AND DISCUSSION

In the operational process of a company, especially those involving physical activity

and the use of work equipment, the risk of work accidents is something that cannot be completely avoided. Based on work accident data for one year, 12 incidents were recorded. Indicating that the work environment still has a high risk to worker safety. This data becomes the basis for evaluating the potential hazards that exist in the work environment and helps companies design more effective preventive measures. The HIRARC (*Hazard identification, risk assessment, and risk control*) method is used in managing the risk of work accidents. The following is a recapitulation of data on work accident incidents in the PT XYZ refinery unit in a one-year period, presented in Table 5.

Table 5 Work accident data

No	Month	Number of Occurrences	Types of Work Accidents	
1	January	1	Scratched right hand while handling hot pipes	Minor Injuries
2	February	1	Eyes are splashed with hot steam during maintenance	Medium Injury
3	March	1	Sprained leg while lifting weights	Minor Injuries
4	April	1	Back bruised from slipping in the tank area	Medium Injury
5	May	1	Exposed to wood chips during welding	Minor Injuries
6	June	1	The hand was crushed in the door of the production area	Medium Injury
7	July	1	Eyes splashed with mild chemicals	Minor Injuries
8	August	1	Falling down the stairs during inspection	Minor Injuries
9	September	1	Scrapes caused by contact with machinery	Minor Injuries
10	October	1	Electrocution during installation or repair	Medium Injury
11	November	1	Hands are crushed by materials when arranging goods	Minor Injuries
12	December	1	Neck hit by iron fragments during pipe repair	Medium Injury

Based on Table 5, a total of 12 work accidents were recorded at the PT XYZ refinery unit over a one-year period, with one incident each month. The second quarter (April–June) showed the highest frequency, accounting for 3 incidents (25%), which may indicate increased operational intensity or maintenance activities during that period. In terms of severity, 7 incidents (58.3%) were classified as minor injuries, such as scratches, mild burns, and chemical splashes, while 5 incidents (41.7%) were categorized as moderate injuries, including electrocution and back bruises.

The most common causes of accidents were contact with hot surfaces or steam (4 cases), exposure to chemicals (2 cases), and slips or mechanical hazards. These patterns highlight

the presence of recurring hazards related to thermal and chemical exposure, reinforcing the importance of proactive risk identification and mitigation strategies. The consistency in the type of incidents across different months also suggests potential systemic gaps in safety procedures or protective measures that require further evaluation.

Based on the results of observations and analysis in the field, it shows that the PT XYZ refinery unit has several hazard risks spread across various work areas, such as the pump, stabilizer, and separator units. The hazards found are mostly related to the physical and chemical properties of the materials used and extreme working conditions, such as high pressure and heat. An example in the pump

work area with identified hazard sources is leakage, identification of slipping hazards, and

environmental pollution. For more details, the hazard risks are presented in the table below.

Table 6 Risk Identification

Work Area	Hazards Source Identification	Hazard Risk Identification
Pump	Leaks	Slipping, environmental pollution
	Smoke from the heating process	Exposure to noxious fumes, respiratory distress
Heat Exchanger	Shell leakage	Pollution
	Heat from the shell	Burns
Stabilizer	High pressure and temperature	Explosion, fire
	Crude oil leak	Fire, explosion, pollution
Furnance	Hot area temperature	Burns
	Noise	Hearing impairment
Evaporator	Cube leakage	Explosion, fire
	Oil/vapor leakage	Fire, explosion, chemical exposure
Condenser	High pressure and temperature	Explosion, fire
	High pressure	Explosion, leakage
Cooler	Coolant/oil leakage	Environmental pollution
	Pipeline pressure and temperature	Explosion, fire, equipment damage
Separator	Pressurized oil and water	Explosion, pollution
	Gas leak	Explosion, fire, gas poisoning

Each identified hazard risk is then assessed using a semi-quantitative approach, where each risk is evaluated based on the *likelihood* and *consequence* values, then classified into risk categories (*risk levels*) such as *Low*, *Moderate*, *High*, and *Very High*. These results form the basis for prioritizing risk mitigation measures to ensure occupational safety and sustainability of the operational environment.

From the results of data processing, it is known that some work areas at PT XYZ, such as Separator, Evaporator, and Stabilizer, have a

risk level classified as *Very High* (VH), especially those related to leakage, high pressure, and the potential for explosion and fire. Meanwhile, areas such as the Cooler and Furnace show *Moderate* to *High* risk levels, depending on the identified hazard sources. Table 7 below presents the results of the risk assessment analysis based on the identification of hazard sources, risk types, likelihood of occurrence, impacts, and risk categories in each work area at the industrial facilities studied.

Table 7 Risk Assessment

Work Area	Hazard Source Identification	Hazard Risk Identification	Hazard Identification					
			Possibilities		Impact		Risk	
			Value	Category	Value	Category	Value	Category
Pump	Leaks	Slipping, environmental pollution	4	<i>Likely</i>	3	<i>Major</i>	12	H
	Smoke from the heating process	Exposure to noxious fumes, respiratory distress	3	<i>Possible</i>	3	<i>Moderate</i>	9	M
Heat Exchanger	Shell leakage	Pollution	4	<i>Likely</i>	3	<i>Moderate</i>	12	H
	Heat from the shell	Burns	2	<i>Unlikely</i>	2	<i>Minor</i>	4	L
Stabilizer	High pressure and temperature	Explosion, fire	3	<i>Possible</i>	5	<i>Catastrophic</i>	15	VH
	Crude oil leak	Fire, explosion, pollution	4	<i>Likely</i>	4	<i>Major</i>	16	VH
Furnance	Hot area temperature	Burns	2	<i>Unlikely</i>	3	<i>Moderate</i>	6	M
	Noise	Hearing impairment	3	<i>Possible</i>	2	<i>Minor</i>	6	M
Evaporator	Cube leakage	Explosion, fire	3	<i>Possible</i>	4	<i>Major</i>	12	H
	Oil/vapor leakage	Fire, explosion, chemical exposure	4	<i>Likely</i>	5	<i>Catastrophic</i>	20	VH
Condenser	High pressure	Explosion, leakage	3	<i>Possible</i>	4	<i>Major</i>	12	H
Cooler	Coolant/oil	Environmental pollution	4	<i>Likely</i>	4	<i>Major</i>	16	VH

Separator	leakage Pipeline pressure and temperature	Explosion, fire, equipment damage	3	Possible	4	Major	12	H
	Pressurized oil and water	Explosion, pollution	4	Likely	5	Catastrophic	20	VH
	Gas leak	Explosion, fire, gas poisoning	4	Likely	5	Catastrophic	20	VH

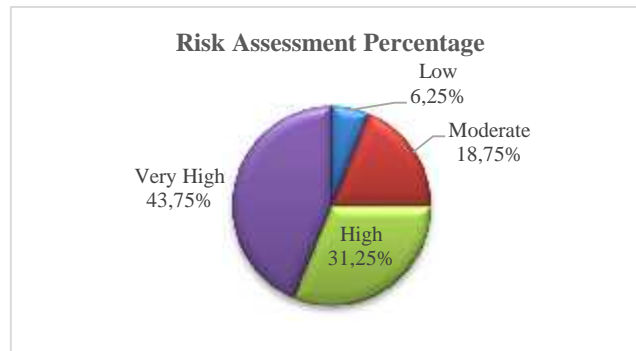


Figure 2: Risk Percentage

Based on the pie chart, it can be seen that most of the risks are in the Very High category (43,75%), followed by High (31.25%), Moderate (18.75%), and Low (6.25%). This information provides an overview of the level of risk faced and can be the basis for determining risk handling priorities.

After identifying and assessing the risks in each work area, the next step is to determine the appropriate form of risk control to minimize potential hazards and their impact on work safety and the environment. Based on field observations and the previous risk analysis, the control strategy focuses on a combination of technical and administrative measures, as well as the use of personal protective equipment (PPE). Although administrative controls such as SOPs, safety training, and PPE usage form an essential part of the risk mitigation strategy, the refinery unit has also implemented a number of engineering and technical controls to directly reduce hazards at the source. These include the installation of automated pressure and temperature alarm systems, routine equipment inspections, and maintenance protocols designed to detect wear and failure risks before incidents occur. Additionally, operational areas are equipped with monitoring instruments that enable early detection of unsafe conditions, particularly in high-risk units like the evaporator and separator. These technical measures

demonstrate that the risk control efforts are not limited to procedural compliance but are backed by practical, system-based interventions that improve real-time responsiveness and enhance overall safety integrity.

Therefore, it can be concluded that the approach to risk control in this study adopts a balanced combination of administrative and engineering strategies, aligning with best practices in industrial safety management and fulfilling the multi-layered protection principle in high-hazard environments. Technical controls such as ventilation systems, temperature/pressure alarms, and gas detection equipment are used to prevent hazardous events early on. Meanwhile, administrative controls in the form of periodic inspections, emergency procedures, worker training, and the implementation of SOPs are also an important part of maintaining operational safety.

Some high-risk areas, such as Separator, Evaporator, and Stabilizer, require stricter controls, including the installation of alarm systems, maintenance of piping systems, and complete use of PPE. Areas such as Pumps and Coolers emphasize routine inspections and periodic repairs to prevent leaks and system damage. With proper and consistent control, the level of risk can be minimized so as to support the creation of a safe, healthy, and productive work environment. Several

technology-based hazard detection systems are relevant for risk assessment in the oil and gas industry. These include Internet of Things (IoT) sensors, which can continuously monitor parameters such as pressure, temperature, and gas concentration in real time; SCADA (Supervisory Control and Data Acquisition) systems, which allow centralized monitoring and automated responses to critical deviations; and

predictive maintenance systems, which use data analytics to forecast equipment failure before it happens. These technologies are increasingly applied in high-risk industrial environments to enhance safety and reduce the reliance on manual supervision. Table 8 below presents the risk control efforts organized by source of hazard, type of risk identified, and preventive and mitigating actions that can be taken.

Table 8 Risk Control

Work Area	Hazard Source Identification	Hazard Risk Identification	Risk Control
Pump	Leaks	Slipping, environmental pollution	Routine inspection, periodic maintenance, leak repair, and fire extinguisher
Heat Exchanger	Smoke from the heating process	Exposure to noxious fumes, respiratory distress	Ventilation system, PPE (mask, respirator), closed system maintenance
	Shell leakage	Pollution	Periodic pressure checks, immediate repair of leaks
Stabilizer	Heat from the shell	Burns	Warning signs, PPE (heat-resistant gloves)
	High pressure and temperature	Explosion, fire	Temperature/pressure alarm, emergency procedures
Furnance	Crude oil leak	Fire, explosion, pollution	Periodic inspections, operator training on emergency procedures
	Hot area temperature	Burns	Heat insulation, PPE
	Kebisingan	Hearing impairment	Use of earplugs/earmuffs
Evaporator	Noise	Explosion, fire	Regular pressure checks, periodic maintenance
	Cube leakage	Fire, explosion, chemical exposure	Routine inspection, pipeline maintenance
Kondensor	Oil/vapor Leakage	Explosion, leakage	Temperature/pressure alarm, emergency procedures
	High pressure		Automatic pressure control, maintenance
Cooler	Coolant/oil leakage	Environmental pollution	Regular check-ups, periodic maintenance
	Pipeline pressure and temperature	Explosion, fire, equipment damage	Pressure & temperature monitoring, system alarms, operating SOPs
Separator	Pressurized oil and water	Explosion, pollution	Safety valve, periodic inspection, pipe maintenance
	Gas leak	Explosion, fire, gas poisoning	Leak alarms, complete use of PPE

Based on the results of the HIRARC analysis, it can be concluded that the PT XYZ refinery unit faces significant risks, especially in activities involving high temperature and pressure. As stated by Fadolly (2021), work in the oil refinery sector requires extra attention to OHS due to the complexity of the process and the involvement of hazardous materials.

Awareness of the importance of using PPE and implementing safe work procedures is one important aspect in minimizing the potential for work accidents (Muhammad & Susilowati, 2021). In addition, the use of automatic gas detection devices and emergency shutdown systems is a technical measure that is increasingly needed in dealing with the threat of explosion or leakage.

In addition to the safety aspect, the efficiency of the production process also affects the level of occupational risk in the field. Research conducted by Pulansari &

Sulaiman (2020) states that the imbalance of production lines can reduce company efficiency and cause bottlenecks, which in turn increases the potential for work backlogs and accident risks at certain points in the operational process. This shows that efficient work planning not only impacts production output but is also an important factor in creating a safer and more controllable work environment.

This research also shows that the HIRARC method is effective in providing a comprehensive overview of potential hazards, risk assessment, and control solutions in a structured and logical manner. The application of this method not only helps reduce work accidents but also increases workers' awareness of a safe and productive work environment.

From the analysis, the activity in the evaporator area is the activity with the highest

risk level (risk value = 20, very high category). This risk mainly comes from the possibility of an explosion due to high pressure and open flames. Followed by the separator with the risk of gas leakage, which is also in the very high category. This result is in line with the view of Kurniati & Sulaiman (2023), which emphasizes that a decline in equipment performance due to undetected degradation can increase the risk of extreme damage, so it is important to set a reliability threshold as an indicator of the timing of preventive maintenance.

Evaluation of existing controls shows that most controls are still administrative in nature, and the use of PPE. Meanwhile, engineering and substitution controls have not been fully implemented optimally, especially in terms of equipment modernization, sensor systems, and emergency *shutdown* automation.

V. CONCLUSIONS AND SUGGESTIONS

The application of the *Hazard Identification, Risk Assessment, and Risk Control* (HIRARC) method in the PT XYZ refinery unit shows that the work environment in the oil processing sector has various

potential hazards with varying levels of risk. Based on the results of identification and analysis, it was found that the evaporator and separator areas are the areas with the highest risk, each having a *very high* category risk score of 20.

Some of the dominant risk factors include explosions due to high pressure, exposure to extreme temperatures, gas leaks, and chemical vapors. Currently, the risk controls implemented still rely heavily on administrative controls and the use of Personal Protective Equipment (PPE), while controls through engineering and substitution have not been implemented thoroughly.

Overall, the HIRARC method proved effective in identifying potential hazards, assessing risk levels, and designing appropriate control strategies according to the control hierarchy. These results indicate that the HIRARC approach is highly relevant to support the Occupational Health and Safety (OHS) management system in the oil and gas industry.

With further research that is more in-depth and uses varied methods, it is hoped that the OHS system in the oil and gas sector can further develop and be able to create a safe, productive, and sustainable work environment.

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