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Health risk assessment at hydro cracker complex oil and gas company

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ABSTRACT

The hydro cracker complex (HCC) operating area is one of the areas with the most use of chemicals, and several workers complain about the noise in that area. This research determines the level of health hazard risk through a health risk assessment (HRA) focusing on physical, chemical, and biological hazards in the HCC area aims to improve the health status of workers and as a basis for developing occupational health programs to minimize the risk of occupational diseases. This study used primary data (walkthrough survey, interviews, heat stress measurements, noise, lighting, chemicals, fungi, and bacteria) with a cross-sectional method referring to the International Council on Mining & Metals (ICMM). The dangers of gasses and chemicals are the most common hazard in the HCC area. Based on the risk assessment, five hazard ratings with the highest risk were obtained, namely noisy environment (extreme), H2S gas (extreme), heat stress (extreme), NH3 gas (high risk), and hydrocarbon vapors (high risk). Existing controls and control recommendations must be applied comprehensively and consistently so that the company can accept the resulting residual risk value.

Kata kunci:

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ABSTRAK

Area operasi hydro cracker complex (HCC) merupakan salah satu area yang paling banyak menggunakan bahan kimia, dan beberapa pekerja mengeluhkan kebisingan di area tersebut. Penelitian ini menentukan tingkat risiko bahaya kesehatan melalui health risk assesment (HRA) yang berfokus pada bahaya fisik, kimia, dan biologi di area HCC yang bertujuan untuk meningkatkan status kesehatan pekerja dan sebagai dasar untuk mengembangkan program kesehatan kerja untuk meminimalkan risiko penyakit akibat kerja. Penelitian ini menggunakan data primer (walkthrough survey, wawancara, pengukuran tekanan panas, kebisingan, pencahayaan, bahan kimia, jamur, dan bakteri) dengan metode cross-sectional mengacu pada International Council on Mining & Metals (ICMM). Gas dan bahan kimia merupakan bahaya yang paling umum terjadi di kawasan HCC. Berdasarkan penilaian risiko diperoleh lima peringkat bahaya dengan risiko tertinggi, yaitu lingkungan bising (ekstrim), gas H2S (ekstrim), tekanan panas (ekstrim), gas NH3 (risiko tinggi), dan uap hidrokarbon (risiko tinggi). Pengendalian yang ada dan rekomendasi pengendalian harus diterapkan secara komprehensif dan konsisten agar perusahaan dapat menerima nilai residual risk yang dihasilkan.

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INTRODUCTION

One of the largest industries driving development and the economy in Indonesia is the oil and gas industry which acts as a source of domestic energy, a source of state revenue and foreign exchange, as well as one of the raw materials for the national industry (Ministry of Energy and Mineral Resources RI, 2022). Oil and gas production in February 2023 reached 1,592.9 million barrels of oil per day (International Energy Agency, 2023). The oil and gas industry business activities include upstream business activities, which include exploration, oil and gas field development, production, extraction of oil or natural gas, and downstream business activities, which include processing, transportation, and marketing activities. The production process of the oil and gas industry is carried out continuously for 24 hours non-stop to meet needs and achieve production targets. OSHA's strategic management plan states that the oil and gas industry is one of seven industries with a hazard and risks where one small mistake can cause a significant accident (Dahlan & Widanarko, 2022).

Potential hazards in the workplace can come from the work environment, work methods, labor, equipment, and materials used in the work process. Health hazards are a hazard encountered in the oil and gas industry in addition to safety hazards (Hasibuan et al., 2020). Health hazards in the oil and gas industry are physical, chemical, biological, ergonomic, and psychosocial hazards (Karimi et al., 2021). The health effects on workers exposed to these hazards depend on the level of exposure, the intensity of the exposure, the duration of the exposure, and the organs exposed (Adliene et al., 2020). Physical hazards in the oil and gas industry include noise, vibration, ionizing radiation, and environmental heat (Benson et al., 2021).

The effects of ionizing radiation are disturbances to the stability of human genes and chromosomes. Environmental heat can cause the danger of dehydration, heat rash, heat cramps, heat syncope, heat exhaustion, and heat stroke. Exposure to benzene dominates chemical hazards in the oil and gas industry. Benzene is a natural component of crude oil and natural gas (Attaqwa et al., 2020). Meanwhile, chronic exposure can cause reduced red and white blood cell production from the bone marrow, decreased immune system, central nervous system damage, slow reflexes, liver and kidney failure, and cancer. Generally, biological hazards in the oil and gas industry are related to poor food safety controls, which can impact digestive problems (Suhardono, 2019).

The HCC area is a downstream processing unit for a petroleum refinery using chemical reactions in its production process. Only 15% of the 100,000 chemicals are known to be dangerous to humans, so the potential for hazards and risks posed by chemical hazards is very high, especially environmental incidents regarding chemical emissions which can cause fires and explosions (Sutrisno et al., 2021). Then exposure to chemicals at work has damaging health effects such as elevated blood and urine chemical concentrations, neurobehavioural deficits and neurological symptoms, mental health issues, oxidative stress and DNA damage, poor growth, asthma, and hypothyroidism (Scott & Pocock, 2021). Therefore, efforts are needed to manage these hazards by conducting health hazard risk assessments to prevent them from causing fatalities, environmental damage/pollution, worker health, material losses, and a declining company reputation.

We conducted research at PT X as an example of a national oil and gas company in the world that has one of the HCC work process units. PT. X is one of the upstream oil and gas companies operating in Pekanbaru and has high productivity and high occupational health and safety hazards in every company's operational activities. PT. X consists of a hydro skimming complex (HSC), heavy oil complex (HOC), hydro cracker complex (HCC), oil movement and utilities, as well as other work units such as maintenance execution, laboratory, HSSE, workshop, warehouse, central control room, and main office. The operational area with the most complex and critical work processes at PT. X is the hydro cracker complex (HCC). HCC is a functional area consisting of several units, namely those consisting of the HCU area (unit 211/212), Amine LPG/SWS (410), and the H2 Plant (unit 701-702). The process in the HCU unit breaks down long hydrocarbon chains into short chains with smaller molecular weights. Heavy vacuum gas oil (HVGO) and high cooker gas oil (HCGO) are processed to produce various fuel products, such as naphtha, light kero, heavy kero, diesel oil, and unconverted oil (UCO). The LPG/SWS Amine unit has a gas refinery treatment process to separate HS gas equipped with an MEA and Antifoam stripper. In the H2 Plant unit, sulfur compounds are removed from the gas to protect the catalyst in the reformer using activated carbon.

The complex work process in a company makes the existing health and safety hazards bigger and can cause work-related accidents and diseases. Occupational accidents and diseases contribute to the deaths of more than 2.3 million workers each year (ILO, 2021) The risks can come from physical, chemical, biological, ergonomic, and psychosocial hazards (OSHA, 2020). The hazards in the HCC area include lack of lighting and indoor air quality, temperature, noise due to engine noise, heat stress, toxic gasses, bacteria, and fungi. These hazards can cause a decrease in work productivity which can trigger it. Suppose the HCC process unit is managed correctly and by internationally accepted safety standards by ISO 45001: 2018. In that case, the company can obtain maximum production results and create safe and secure work processes by implementing an OHS management system (Heras-Saizarbitoria et al., 2020).

Based on the backround described, This research is conducted to obtain an HRA (Health Risk Assessment) from PT.X as a foundation for developing an occupational health program to minimize the risks of occupational diseases and as a recommendation for control measures in similar industries.

METHODS

This research was semi-quantitative research with an observational method. The semi-quantitative method was opted for due to its capacity to facilitate a more straightforward determination of control priorities compared to other methods, this approach is also more reliable than the qualitative method because it considers matrices of consequences and exposure probabilities. The research objective was to determine the level of health hazard risk focused on physical, chemical, and biological hazards in the HCC area of PT. X to improve worker′s health status and as a basis for developing occupational health programs to minimize the risk of occupational diseases.

The results of a walkthrough survey conducted in the PT. X HCC area is needed to determine the types of parameters, sample points, and equipment used in measuring health hazards at PT. X as follows (Table 1).

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Table 1.
List of Parameter Types, Sample Points, and Health Hazard Measurement Equipment

No	Parameter		Sample Point	Equipment Items
1.	Heat stress		2	Thermal Environment Monitor
2.	Lighting		1	Light Meter
3.	Noise	Personal	2	Noise Dose Meter
		Environment	4	
4.	Benzene, Toluene, Xylene (BTX)	Personal	2	Charcoal + Pump
		Environment	1	
7.	n-hexane		1	Charcoal + Pump
8.	Total Hydrocarbons		1	Charcoal + Pump
9.	Hydrogen Sulfide (H2S)		2	Air Sampler Impinger
10.	Ammonia (NH3)		2	Solid Sorbent Tube + Pump
11.	Carbon Monoxide (CO)		1	CO monitor
12.	Indoor Air Quality		1	Environmental Monitor

In this research, measurements will be taken concerning heat stress, lighting, personal and environmental noise, personal and environmental BTX, n-hexane, total hydrocarbons, H2S, NH3, CO, and indoor air quality. The sampling points, several Specific Exposure Groups (SEGs), and the list of the instruments to be utilized for measuring are shown on the table above.

This study uses primary data (walkthrough survey, interviews, measurements of heat stress, noise, lighting, chemicals, and bacteria) conducted in the HCC area of PT. X with a cross-sectional method. Before being utilized, all testing instruments in this research have been calibrated by relevant authorities to guarantee its validity and reliability. The data obtained is then analyzed to determine the rating and level of health hazard risk (extreme, high risk, medium risk, low risk) as well as control of the hazards and possible risks by using analytical methods that refer to the International Council on Mining & Metals (ICMM). Based on ICMM (ICMM, 2016), there are a total of 13 steps undertaken to do Health Risk Assessment.

The implementation stage in making Health Risks is the first step to identifying hazards, sources, and health impacts through report data and documents related to OSH in the HCC area of PT. X, with a crossroads survey, then determines the rating of each hazard found. Following the secondary data collection, a brief walk-through survey is conducted. The objective of this activity is to gain an understanding of the types of health hazards present in the workplace, exposure levels, job categories, and the health status of workers. Subsequently, ratings are assigned to each identified hazard. Furthermore, from all the hazards found, workers are grouped based on the potential exposure to the same hazard (similar exposure group) to calculate the level of risk workers receive.

Then identify processes, tasks, and work areas where potential exposure could occur. Some things that are needed to be reviewed to identify and assess processes, tasks and areas of potential danger are processes and tasks, machines and equipment, work environment and locations, health surveillance records.

Assess, measure, and verify exposure. Then conduct a study of potential health risks such as duration, frequency, and level of exposure compared to applicable standards. Next, set the level of risk based on the rating such as low, medium, or high. Then identify the controls that PT has owned. X and assess the effectiveness of these controls. Identify the controls based on hierarchy of controls that include elimination, substitution, technical controls, administration controls, and PPE.

Next, make a list of risks and controls for these potential risks. After that, determine risk acceptance and priority actions. After that, they monitor and review risk controls and corrective actions to take control of controls immediately. Maintain accurate HRA records, change existing risk control action plans, and employ additional control measures. Monitor and review regularly if there are new developments or changes to the process. The HRA process flow chart is as follows.

PT. X uses a 5 x 5 table risk matrix in risk assessment to obtain risk category values based on the severity and probability level adopted by the company. According to the International Petroleum Industry Environmental Conservation Association (IPIECA) and the International Association of Oil & Gas Producers (OGP), the risk matrix with a 5 x 5 table is more objective. It makes it easier to carry out a risk assessment of newly identified hazards with a scale of 5 points or 5 rating levels so that each component, both severity level and probability level, can be analyzed more accurately. After conducting an ethical review concerning research ethics codes, potential ethical issues, research design, and other factors, the study has been deemed ethically approved with the reference number Ket-649/UN2.F10.D11/PPM.00.02/2023 by Fakultas Kesehatan Masyarakat Universitas Indonesia. Additionally, the researcher obtained the respondents' consent through an informed consent letter regarding the study before commencing data collection to ensure their agreement.

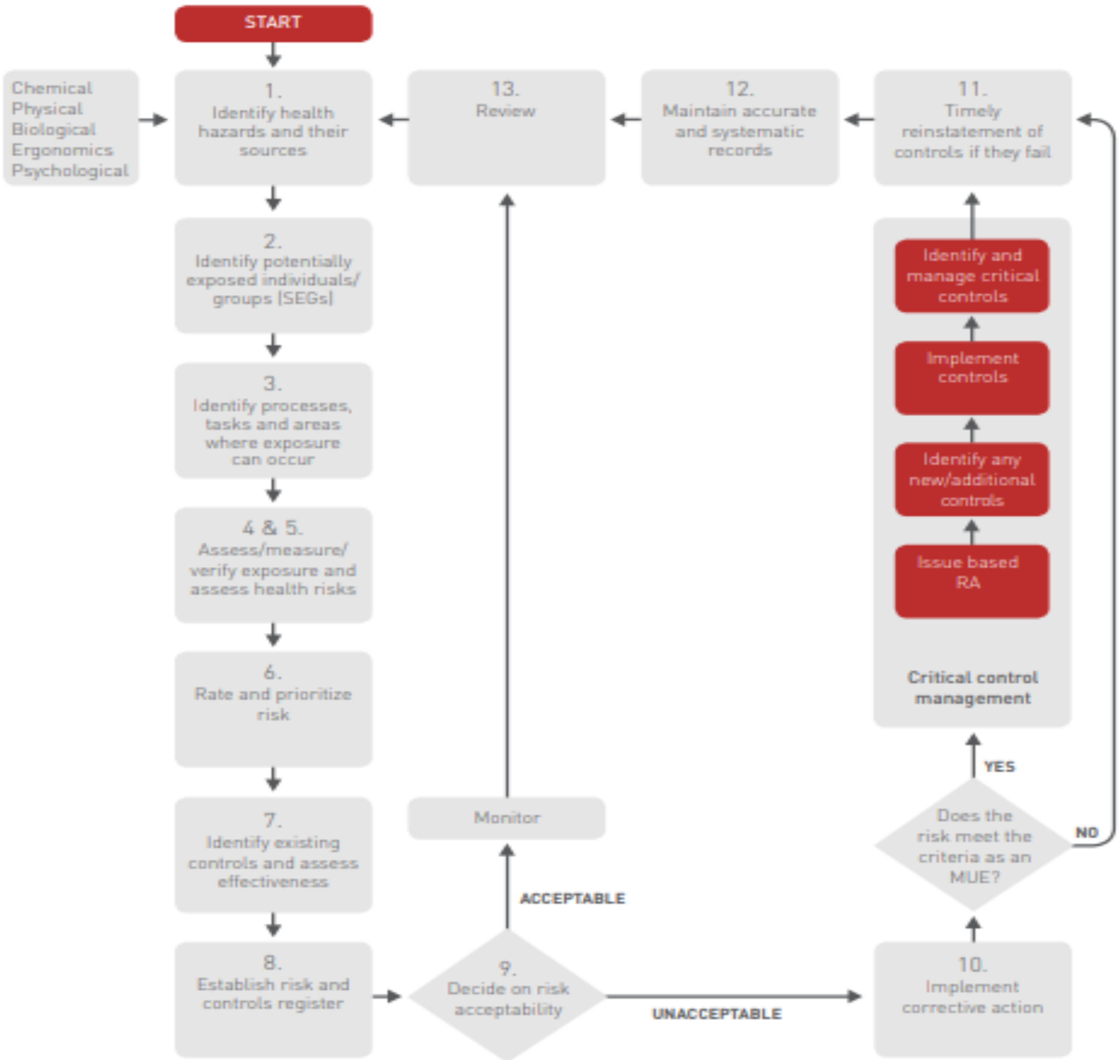

Figure 1. Health Risk Assessment Process
Source: International Council on Mining & Metals (ICMM, 2016).

Table 2
Work Groups in the HCC Unit

Position		Daily/Shift	Number of People
Section Head		Daily	1
Team support facility and quality	Facility	Daily	1
	Lead HCU dan H_2 Plant	Daily	2
Field operator	Amine	Daily	2
	H_2 Plant	Daily	3
	HCU Rx	Daily	6
	HCU Fx	Daily	4
Panel Man	HCU Rx & Fx	Shift	3
	H_2 Plant	Shift	2

RESULTS OF STUDY

Based on the data collection which was carried out on the determinded sampling points and similar exposure groups (SEG), that was chosen by the results of the walk-through surveys in every location or work unit, these are the hazard that was found in HCC area. Workers in the HCC area consist of daily and shift workers, as described in Table 2.

Most daily workers in the field operator section are in the HCC unit and have routine tasks such as conducting patrols, operating pumps, reactors, and fin fans, making up catalysts and chemicals, taking samples, and standing by at the campo. Based on work areas and activities, There are several similar exposure groups (SEG) in the HCC unit: section head, panel man, amine field operator, H2 plant field operator, HCU Rx field operator, and HCU Fx field operator. Measurement of health hazard risks in the PT. X HCC area is carried out on workers who have been grouped into several similar exposure groups (SEG) at several location points for measuring physical, chemical, and biological health hazard risks by considering the frequency and duration of exposure and taking into account the severity and probability of accidents so that the level of risk accepted by workers.

Table 3
Health Hazards in The HCC Area of PT X

Unit	Location	Exposed Worker	Health Hazard		
			Physical	Chemical	Biology
HCU	Pump	Field operator HCU Rx	• Noise • Heat stress	• Benzene Vapor • Non-carcinogenic hydrocarbon vapors • CO gas • H_2S gas • Contact with lube oil	-
	Heat exchanger	• Panel Man HCU Rx • Field operator HCU Rx	• Noise • Heat stress	• Benzene Vapor • Non-carcinogenic hydrocarbon • CO gas • H_2S gas • NH_3	-
	Reactor	Field operator HCU Rx	• Heat stress	• Benzene Vapor • Non-carcinogenic hydrocarbon • CO gas • Sulfiding agent	-
	Column and Vessel	• Panel Man HCU Rx • Field operator HCU Rx	• Noise • Heat stress	• Benzene Vapor • Non-carcinogenic hydrocarbon • CO gas • H_2S gas	-
Amine, LPG Recovery, SWS	Pump	Field operator amine	• Noise • Heat stress	• CO Gas • H_2S Gas	-
	Column and Vessel	Field operator amine	• Noise • Heat stress	• Benzene Vapor • Non-carcinogenic hydrocarbon • CO Gas • H_2S Gas	-
	Fin fan	Field operator amine	• Noise • Heat stress	-	-
	Strippers	Field operator amine	-	Mono Ethanol Amine (MEA)	-
H_2 Plant	Heat exchanger	• Panel Man H_2 Plant • Field operator H_2 Plant	• Noise • Heat stress	• CO_2 Gas • C1 - C5	-
	Desulfurization reactor	Field operator H_2 Plant	• Noise • Heat stress	• H_2S Gas • CO Gas • C1 - C5	-
	Steam Reformer	• Panel Man H_2 Plant • Field operator H_2 Plant	• Noise • Heat stress	• CO Gas • DEA • MEA	-
	Benefil System	Field operator H_2 Plant	·	• K_2CO_3 • DEA • MEA	-

Based on Table 3, the health hazards contained in the HCC area are chemical hazards and physical hazards. Chemical hazards are dominated by various gases and hazardous chemicals (H_2S gas, CO gas, Benzene, Non-carcinogenic hydrocarbons, MEA, etc.), and physical hazards are dominated by noise and heat stress. In the 3 units studied, no biological hazards were found, this conclusion is based on the walk-through survey conducted and the previous Hazard and Risk Assessment (HRA) data available from PT.X, which indicated that the area does not pose any biological hazard issues. Therefore, further measurements for biological hazards were not deemed necessary.

After identifying the hazards in the 3 units, measurements of these hazards are carried out using the equipment listed in Table 1. The measurement results are then charted according to 5x5 risk assessment matrix outlined in Table 4.

Table 4
Measurement of Health Hazard Risks in The HCC Area of PT X

Unit	SEG	Measurement Results	F/D	JD	C	L	C x L	RC
HCU	Field Operator HCU Rx	Personal Noise (TWA) 79,6 dBA Environmental Noise (Leq)	3x	5 minute	2	1	2 (no need for immediate action)	• Regulation of the Minister of Health of the Republic of Indonesia No. 70 of 2016 about Work Industry Environmental Health Standards and Requirements • Republic of Indonesia Minister of Health Regulation No 48 of 2016 about Office Health and Safety Standards (Noise exposure in the environment) • Republic of Indonesia Minister of Manpower Regulation No 5 of 2018 about Occupational Health and Safety Work Environment.
	Field Operator HCU Rx	• 66,5 dBA (Campo HCU Rx)	Standby officer on site	Standby officer on site	5	4	20 (urgent to be addressed)	
	Field Operator HCU Rx	• 67,5 dBA (Campo HCU Fx)	Standby officer on site	Standby officer on site	5	4	20 (urgent to be addressed)	
	Field operator HCU Rx	Heat Stress 39,2^{0}C (Heater 701 & 702)	12x	15 minute	4	4	16 (urgent to be addressed)	
	Field operator HCU Rx	Gas CO (Heater area 211) 0,24 mg/m^3	3x	10 minute	1	1	1 (no need for immediate action)	
	Field operator HCU Rx	Gas H_2S (Vessel HCU area unit 211/212) 0,17 ppm	3x	15 minute	3	2	6 (must be handled)	
	Field operator HCU Rx	Benzene (Operator HCU Rx unit 212) <0,001 ppm	3x	5 minute	2	1	2 (no need for immediate action)	
	Field operator HCU Rx	Toluene (Operator HCU Rx unit 212) <0,001 ppm	3x	5 minute	2	1	2 (no need for immediate action)	
	Field operator HCU Rx	Xylene (Operator HCU Rx unit 212) <0,006 ppm	3x	5 minute	2	1	2 (no need for immediate action)	
	Field operator HCU Rx	Hexane (Unibon Fx area) <0,1 ppm	3x	10 minute	2	1	2 (no need for immediate action)	
Amine, LPG Recovery, SWS	Field operator amine	Environmental Noise (Leq) 67,8 dBA (Campo Amine SWS)	Standby officer on site	Standby officer on site	5	4	20 (urgent to be addressed)	• Regulation of the Minister of Health of the Republic of Indonesia No. 70 of 2016 about Work Industry Environmental Health Standards and Requirements • Republic of Indonesia Minister of Health Regulation No 48 of 2016 about Office Health and Safety Standards (Noise exposure in the environment) • Republic of Indonesia Minister of Manpower Regulation No 5 of 2018 about Occupational Health and Safety Work
	Field operator amine	NH_3 Gas (amine & LPG area) 16,21 ppm	24x	1-15 minute	4	3	12 (dealt with immediately)	
	Field operator amine	H_2S Gas (SWS area) 1,17 ppm	24x	1-15 minute	5	4	20 (urgent to be addressed)	
	Field operator amine	Benzene <0,005 ppm (SWS area)	3x	10 minute	2	1	2 (no need for immediate action)	
	Field operator amine	<0,001 ppm (Operator Amine) Toluene	3x	5 minute	2	1	2 (no need for immediate action)	

	Field operator amine	<0,005 ppm (Area SWS)	3x	10 minute	2	1	2 (no need for immediate action)	Environment
	Field operator amine	<0,001 ppm (Operator Amine)	3x	5 minute	2	1	2 (no need for immediate action)	
		Xylene						
	Field operator amine	<0,02 ppm (SWS area)	3x	10 minute	2	1	2 (no need for immediate action)	
	Field operator amine	<0,006 ppm (Operator Amine)	3x	5 minute	2	1	2 (no need for immediate action)	
	Field operator amine	Hydrocarbon (Amine & LPG Recovery area) 32,12 ppm	3x	10 minute	4	2	8 (dealt with immediately)	
H2 Plant	Field operator H_2 Plant	Personal Noise (TWA) 78.7 dBA	12 x	1-30 minute	1	1	1 (no need for immediate action)	• Republic of Indonesia Minister of Health Regulation No 48 of 2016 about Office Health and Safety Standards (Noise exposure in the environment) • Republic of Indonesia Minister of Manpower Regulation No 5 of 2018 about Occupational Health and Safety Work Environment
	Field operator H_2 Plant	Environmental Noise (Leq) 68,1 dBA (Campo H_2 Plant)	Standby officer on site	Standby officer on site	5	4	20 (urgent to be addressed)	

F/D = frequency per day. JD = job duration. C = consequences. L = likelihood. C x L = assessment. RC = regulatory compliance.

Table 5
Risk Ranking of Health Hazards in the HCC Area of PT. X

Risk		Assessment		Level of Risk
What can happen?	How can happen?	Consequences	Likelihood	
Hearing loss (noise-induced hearing loss)	Environmental noise	5 (Catastrophic)	4 (Likely)	20 (Extreme)
Impaired central nervous system or central nervous system (CNS) damage	H_2S gas	5 (Catastrophic)	4 (Likely)	20 (Extreme)
Dehydration, heat rash, cramps, syncope, heat exhaustion, and heat stroke.	Heat stress	4 (Significant)	4 (Likely)	16 (Extreme)
Lung damage	NH_3 gas	4 (Significant)	3 (Moderate)	12 (High Risk)
Cancer	Hydrocarbon vapor	4 (Significant)	2 (Rare)	8 (High Risk)

Based on Table 4, the risk level can be identified based on the red color symbol, which means extreme; the orange color, which means high risk; the yellow color, which means medium risk; and the green color, which means low risk. The hazard that is the majority or dominant and the highest risk in the PT. X HCC area is a physical hazard (noise and heat stress) and a chemical (H_2S gas, NH_3 gas, and hydrocarbon vapor).

Based on the regulations listed in Table 4, it is stated that any hazard or risk exceeding the threshold values in those regulations must be subject to control measures. Therefore, several hazards and risks have been identified and control measures have been implemented by PT.X, such as in the case of noise and chemical compounds. However, based on our findings, some of these controls have not been implemented sufficiently effectively.

DISCUSSION

Based on the table analysis of health risk assessment (HRA) results in Table 4, we conclude that the top 5 hazards and risk ratings in the HCC area of PT. X as presented in table 5.

Table 5 shows the top 5 hazards and risk ratings in the HCC area of PT. X. The top 5 include hazards and risk that have undergone the predetermined threshold limit value (TLV). Although in the case of measurement NH3, it did not exceed the TLV, the NH3 level exceeded 50% of the TLV, resulting in an elevated risk assessment to account for the worst-case scenario. The focus and needs special attention and immediate treatment are physical hazards and chemical hazards are listed. The physical hazards present are noise and heat stress hazards. At the same time, the chemical hazards are in the form of H_2S gas, NH_3 gas, and hydrocarbon vapors. Companies need to control physical and chemical hazards that exceed the permissible threshold limit value (TLV) so that these hazards do not create unwanted risks, work-related illnesses, and accidents that harm workers and reduce levels.

Extreme Risk Category

Noise

Based on research conducted by Lestari, A. S. (Lestari, 2021) in a Public Health Journal, the potential for noise hazards originates from the water injection pump (WIP) pump engine at the oil collection station and in the power plant, which originates from generator engines and fan radiators which function as providers electrical energy for all areas of the company. Meanwhile, according to Hossain and Howladar (Hossain & Howladar, 2022), several things that can cause noise in equipment and machines include operating obsolete production machines with non-routine maintenance systems and machines often operated with high work capacity in long operating periods—at the same time, measuring noise exposure in the HCC area of PT. X exceeds the TLV, namely Leq of 68.1 dBA; Leq should be noise exposure by the Regulation of the Minister of Health of the Republic of Indonesia No. 48 of 2016, namely 55-65 dBA, as for noise exposure in the HCC area of PT. X comes from the operation of production machines such as the operation of heat exchangers, heat heaters, sour water strippers (SWS), amine & LPG recovery, fuel gas systems, distillation columns & drum separators, compressors, and steam production processes (Ratnasari, 2018).

Noise-induced hearing loss (NIHL) is hearing loss due to excessive noise exposure. Hearing damage can be in the form of a temporal threshold shift (Temporary Threshold Shift-TTS) or a permanent hearing threshold shift (Permanent Threshold Shift-PTS) after being exposed to noise for a certain period without adequate protection. Noise can also cause psychological disturbances that cause loss of worker concentration, affecting work performance and reducing work productivity. Another impact of noise is that it can affect errors in communication or work instructions that can endanger worker safety (Simpson & Horberry, 2016). In another study conducted by Khajenarisi, it was also known that some noise at 110 dB could lead to disturbance and affect individuals' performance; these decreases were found in both manual and mental activity (Khajenasiri, 2016).

Noise management is needed to control noise hazards in the workplace based on a control hierarchy starting from hazard elimination, substitution, engineering control, administrative control, and the use of appropriate PPE. The control efforts that PT X has carried out to address the noise hazard due to machines operating in the HCC area are engineering control efforts by isolating machines that cause noise and administrative control by enforcing standard operating procedures (SOPs) working in areas with noise hazards such as regulation of working hours, duration of exposure, use of complete PPE and additional PPE such as the use of earplugs and earmuffs, installation of safety signs, posters and safety signs, and provision of PPE in the workplace. However, the control efforts made so far are insufficient, considering that the environmental noise measurements have reached 68.1 dBA. Based on the observations, it is evident that the workers' consistency in using Personal Protective Equipment (PPE) such as ear protection is still very low. Additionally, seals have not been installed in some areas, allowing noise to penetrate the areas where workers pass through.

Based on research conducted by Ratnasari (Ratnasari, 2018) regarding the HRA of chemical and physical hazards in the HCC area, several recommendations for action against noise hazards include installing seals in cracks such as windows and doors as an effort to control engineering control of campo so that noise from the functional area does not enter the campo area. Then control efforts with administrative control, namely setting the duration of exposure to noisy environments and implementing a comprehensive hearing protection program for worker consistency in using PPE related to the current level of risk.

Hydrogen Sulfide (H_2S)

Based on the Energy Reports Journal regarding the disturbance of H_2S gas in the work environment, the results of research by Al-Khori *et al.* (Al-Khori et al., 2021) stated that the work unit in the refinery area produces exhaust gas in the form of hydrogen sulfide (H_2S) because if you want to use it as a fuel, you have to remove the sulfur content in petroleum first. After all, sulfur can cause engine corrosion when present in the fuel. In this study, H_2S gas came from compressor engines, pumps, pipes, reactors, and vessels. More specifically, it originates from connections due to deteriorating material conditions, such as flange connections, and rubber seals from production equipment that experiences mechanical movement, such as pumps or valves. H_2S gas in the HCC area of PT. X comes from production machines such as heater operation and sour water stripper (SWS) (Ratnasari, 2018). The measurement of H_2S exposure stated that it exceeded the TLV, which was 1.17 ppm. The TLV of H_2S exposure should have been by the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018, which is 1 ppm. These measurements are significantly higher when compared to the measurements conducted at PT X in 2013, which indicated that the measurement values for all units were below the Threshold Limit Value (TLV), with the highest value at 0.36 ppm (Herlianty, 2013).

The control efforts that the company has carried out against the dangers of H_2S gas are administrative controls with regulations that require the use of complete PPE and additional PPE, as well as the installation of safety signs, posters, and safety signs. Due to the high level of H_2S, PT.X also has taken control measures in the company, such as providing respirators to workers. However, the proper use of these respirators has not been consistently observed, as evidenced by observations in the HCC area. Therefore, a program that supports the control efforts undertaken by PT.X is needed.

H_2S is a flammable, highly toxic gas that smells like rotten eggs and is colorless. Based on the American National Standards Institute (ANSI), H_2S levels of 10 ppm can cause eye irritation, 27 ppm causes unpleasant odor, shortness of breath, and intolerance, 100 ppm causes coughing and impaired sense of smell, 200-300 ppm causes swelling of the eyes and a feeling of dryness in the throat, 500-700 ppm can cause loss of consciousness and within 30 minutes-1 hour can cause death, and more than 700 ppm causes loss of consciousness more quickly and continues to death. Based on research conducted by Ratnasari mentions several recommendations for action against H_2S hazards in the HCC area, namely administrative control efforts by determining the duration of exposure and implementing respiratory protection programs for worker consistency in using PPE related to the current level of risk (Ratnasari, 2018).

Heat Stress

One of the physical hazards in the oil and gas industry is heat stress. Heat stress is a physical and physiological reaction due to a combination of a hot work environment in the form of air temperature, air humidity, air velocity, and radiation temperature with human body heat, which is beyond work comfort. Hot temperatures can affect body heat regulation, which affects health. During exposure to heat stress (heat stress), the body will respond naturally by sweating and flowing more blood to the skin to maintain internal body temperature to remain within average temperature (36-37.5^{0}C).

Based on research conducted by Ratnasari, the danger of heat stress in the HCC area comes from the work of operating heat exchangers, sour water strippers (SWS), distillation columns & drum separators, and steam production processes (Ratnasari, 2018). This area is also a source of heat stress in the HCC unit of PT. X. The measurement of heat stress exposure in the HCC area of PT. X stated that it exceeded the TLV of 39.2^{0}C, the TLV of heat stress exposure for moderate category work should be by the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018, which is 32^{0}C. The dangers of heat stress in the workplace can cause health problems for workers, including heat rash, heat cramps (muscle spasms or cramps), heat syncope (condition of loss of consciousness or fainting), and heat exhaustion (fatigue due to lack of body fluids or blood volume), and heat stroke with symptoms such as convulsions, coma, headaches, and even death (Morris & Patel, 2023). Based on data from the Bureau of Labor Statistics, a study in America conducted on outdoor workers showed that during 2011-2019 there were 144 worker deaths (41.9%) caused by exposure to environmental heat. Exposure to heat (heat stress) can endanger the health and safety of workers resulting in a decrease in work productivity and delays in the production process if not immediately controlled (U.S. Bureau of Labor Statistics, 2022).

The control efforts that PT X has carried out against the H2S gas hazard, namely administrative control with regulations requiring the use of complete PPE and additional PPE, namely coveralls to prevent heat exposure to workers both from machines and direct sunlight and installation of posters, as well as safety signs. However, this research shows that heat stress exposure has exceeded the TLV (> 32^{0}C). This shows that the controls that have been implemented by the company have not been effective in reducing the hazard of H2S gas. Based on The Occupational Safety and Health Administration (OSHA), several recommendations can be made by PT X for control efforts to prevent or reduce the risk of exposure to heat stress in the workplace with engineering controls, namely installing general ventilation, installing exhaust fans, installing dust collectors, using barriers (shielding) to reduce radiant heat, Make rest areas and drinking water available that are easily accessible to workers. Administrative control, such as making SOPs for working in hot environments related to working time, workload, work patterns, rules requiring drinking water, acclimatization programs (adaptation adjustments to the work environment), educational programs, and health promotion related to working in hot environments. , an emergency response training program related to heat illness. Furthermore, use work clothes that are by the activities of workers in the workplace.

High-Risk Category

Ammonia Gas (NH_3)

Ammonia (NH_3) is a gas in solid particles present in the air, even in unpolluted conditions. NH_3 is commonly used in the industrial world as an additive and is a potential hazard in the work area, especially in the oil and gas industry. NH_3 in the oil and gas industry comes from fractionation waste (Shahbaz et al., 2023). Based on Al-Janabi's book (Al-Janabi, 2020), NH_3 gas is present in activities in the crude distiller's initial processing unit in the processing of fuel oil production. Meanwhile, NH_3 gas in the HCC area comes from operating the distillation column & drum separator, amine & LPG recovery, heat exchanger, sour water stripper (SWS), distillation column & drum separator, and the steam production process. The measurement of NH_3 exposure in the HCC area was 16.21 ppm. Meanwhile, based on the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018, TLV exposure to NH_3 gas is 25 ppm, so the likelihood of NH_3 in the HCC area is in the category > 50% - 100% TLV. At 16.21 ppm, the presence of NH3 can result in discomfort for workers as the odor of NH3 can be detected at concentrations as low as 5 ppm, and at levels of 10-20 ppm when mixed odors are present (National Research Council (US) Committee on Acute Exposure Guideline Levels, 2008).

Small-sized particulate NH_3 and gas will enter the lungs, bind to the blood, and then channel into the body (Padappayil, 2023). Meanwhile, large NH_3 particulates will survive in the upper respiratory tract and cause swelling and narrowing, eventually interfering with human breathing and resulting in shortness of breath (Butarbutar & Windusari, 2019). NH_3 gas is very toxic, even in low concentrations. When exposed to NH_3 gas, chronic effects can irritate the nose, throat, and lungs, causing bronchitis, brain malfunctions, and decreased blood pressure. The acute effects due to NH_3 exposure at concentrations of 40-70 ppm can cause nose, throat, respiratory, and eye irritation (blindness), whereas at concentrations > 500 ppm can cause death (Firdaus, 2018).

The control that PT. X has carried out against the dangers of NH_3 gas in the HCC area in administrative control with regulations requiring the use of complete PPE and additional PPE, namely respirators, and the installation of safety signs, posters, and safety signs. However, the controls that have been implemented by the company have not optimally protected workers from the dangers of NH3 gas because this research shows that NH3 exposure is in the category >50% - 100% of the TLV and can cause discomfort when working. Several recommendations from previous studies that PT X can make to control the dangers of NH3 gas in the workplace, namely administrative control by setting the duration of exposure and implementing a respiratory protection program for worker consistency using PPE related to the current level of risk (Ratnasari, 2018). Then facilitate the consistency of using PPE with a procurement, replacement, training, and supervision system, as well as giving rewards and punishments.

Hydrocarbon Vapor

Based on the Agency for Toxic Substances and Disease Registry (ATSDR), some of the hazardous and toxic chemicals contained in crude oil are hydrocarbon vapors such as TPH (Total Petroleum Hydrocarbon) and Polycyclic Aromatic Hydrocarbons (PAHs). Hydrocarbons are organic compounds with hydrogen and carbon as constituent components. Oils with longer carbon chains in the hydrocarbons have a higher level of toxicity. Based on research by Andayani *et al.* (Andayani et al., 2021) in a Technical Journal, the dangers of gaseous hydrocarbons are present in the pyrolysis process, namely the process of cracking hydrocarbons with heat (thermal) from steam also called steam cracking by heating in a heat exchanger.

Furthermore, sources of exposure to hydrocarbon vapors, according to research by Rina and Rachmawati (Rina & Rachmawati, 2022) in the Prepotif Journal of Public Health, are found during sampling work activities at the refinery and during the process of analyzing hydrocarbon condensate in the laboratory. At the same time, the hydrocarbon vapors in the HCC area come from the operation of production machines such as the operation of heat exchangers, reactors or absorbents, distillation columns & separator drums, and routine sampling (Ratnasari, 2018). Hydrocarbon vapor measurements in stream sampling activities showed 32.12 ppm (> 10% - 50% TLV). Meanwhile, the TLV of exposure to hydrocarbon vapors should be by the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018, which is 200 ppm.

Hydrocarbons are a compound that can harm health in the form of cancer (Kuppusamy Saranya and Maddela, 2020). Hydrocarbons that enter the human body can cause respiratory tract disorders, nervous disorders such as eye irritation, coughing, and skin spots, reproductive disorders such as changes in the genetic code, internal organ disorders such as aspiration pneumonia or interstitial inflammation of the lungs, liver, and others, and can cause death if in significant concentrations (Ince & Ince, 2019). The control that PT X has carried out against the dangers of hydrocarbon vapors is administrative control with regulations requiring the use of complete PPE and additional PPE, namely respirators, and the installation of safety signs, posters, and safety signs. Even though hydrocarbon exposure is still in the controlled category (> 10% - 50% TLV), more optimal control is still needed than administrative controls and PPE because of the high level of hydrocarbon consequences. Various attempts are needed to control the hazards of hydrocarbon vapors, including installing a ventilation system in the form of an exhaust fan that sucks in hydrocarbon vapor contaminants from condensate inspection activities and storage of other chemicals based on research by Rina and Rachmawati (Rina & Rachmawati, 2022). Based on previous research, recommendations for action against the hazard of hydrocarbon vapors in the HCC area in an oil and gas company, namely control efforts with engineering control in the form of designing a closed hydrocarbon sampling system and closing the sump pit area in unit operations and ensuring smooth flow so that workers do not expose to toxic fumes and gasses (Ratnasari, 2018). Furthermore, the respiratory protection program for worker consistency in using PPE is related to the level of risk involved.

LIMITATION OF THE STUDY

The health risk assessment in this study only focuses on 3 types of hazards, namely physical, chemical, and biological hazards. Several other types of health hazards such as ergonomic and psychosocial hazards are not included in this research and may be affecting several results such as the lack of knowledge about other factors like ergonomics and psychosocial aspects that can result in work-related illnesses or reduced man-hours due to employee fatigue. Therefore it may also be important to include other type of hazards in order to get a more comprehensive picture of the health risks that may occur in a company.

CONCLUSION AND RECOMMENDATION

Based on research results related to health risk assessment (HRA) in the hydrocracker complex (HCC) area of PT. X, it can be concluded that workers divided into a similar exposure group (SEG) in the HCC area have a high health risk from physical and chemical hazards. Based on the risk assessment, we get the five highest risk ratings for physical and chemical hazards: noise, H_2S gas, heat stress, NH_3 gas, and carcinogenic hydrocarbon vapors. PT. X must ensure that existing controls and control recommendations are applied comprehensively and consistently so that the company can accept the resulting residual risk value. Overall the highest health risk is noise exposure, it is recommended that PT.X carry out engineering improvements by installing seals and increasing workers' consistency in using hearing protection equipment. Apart from that, other chemical hazards exposure is also a concern, this exposure can be reduced by using respirators and increasing the consistency of PPE use. Then hazards with a risk category with a medium risk level that is colored yellow must still be considered with control efforts, which can be administrative control because it is a hazard the company must handle. Following the recommended control measures, its also suggested that PT.X should undertake ongoing monitoring of high hazards and risks to ensure the effectiveness of the implemented controls. Establish KPIs for these controls before taking any control measures, conduct regular monitoring, review and adjust the KPIs as needed, and ensure thorough documentation and archiving for tracking control measures.

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