Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri

Vol. 10, No. 1, 2024

Analysis Risk K3 Using JSA and HIRARC Methods Phosphoric Acid Factory on PT. Petrokimia Gresik

Muhammad Khoiru Rozikin[1], Hidayat[2], Akhmad Wasiur Rizqi[3]
Industrial Engineering Study Program, Faculty Engineering, Muhammadiyah University Gresik
Jl. Sumatera No. 101 Randuagung, Kecamatan Kebomas, Kabupaten Gresik, Jawa Timur, 61121
Email: mkhoirurozikin17@gmail.com, hidayat@umg.ac.id, Akhmad_wasiur@umg.ac.id

ABSTRACT

PT. Petrokimia Gresik is one of the industries that produce fertilisers, non-fertilizers, and other chemicals. PT. Petrokimia Gresik is divided into several departments, including the phosphoric acid factory. This research aims to identify and reduce potential hazards during the production process. This research uses (JSA) method to identify the hazard stage and (HIRARC) method to conduct risk analysis. Based on the risk hazard identification results, each job will be assessed based on severity and likelihood to establish the risk level. The research found that all extreme-risk jobs had 4 risks, high risks had 15 risks, medium risks had 2 risks, and no jobs with low-risk levels were found. The control plan carried out in this study is to control by elimination, engineering, administration, and personal protective equipment (PPE).

Keywords: *Occupational Health Safety, JSA, HIRARC.*

Introduction

In the era of globalisation, when free-market competition is getting tighter, and the industrial sector is gradually expanding, the need for healthy and productive employment is becoming increasingly important. As a result of these developments, it is necessary to pay attention to Occupational Safety and Health (K3). Occupational Safety and Health (K3) must be a serious concern in employment, and it continues to develop today, as emphasised by the Ministry of Manpower. Based on data for 2023, businesses with zero work accident rates of around 1,812 experienced an increase of 3.8% compared to 2022, namely around 1,747 companies. Implementing Occupational Safety and Health (K3) is one way to create a work environment that is safe, healthy and free from environmental hazards. This can reduce the risk of workplace accidents and illnesses, increasing productivity and efficiency (Depkes, 2009).

According to health regulations outlined in PBB no. 23 of 1992, every workplace must implement workplace health initiatives to prevent health problems for employees, their families, the general public and the surrounding environment (Depkes, 2009). Industry in Indonesia is improving rapidly, largely due to advances in science and technology. This development is marked by the increasing number of industries established in Indonesia, one of which is PT. Petrokimia Gresik. PT. Petrokimia Gresik is an industry that produces fertilizer, non-fertilizers, and other chemicals. PT. Petrokimia Gresik is divided into several departments, including the phosphoric acid factory. The phosphoric acid factory produces phosphoric acid with a P2O5 content of 54%. This factory has by-products, namely phosphogypsum and fluosilicic acid (H2SiF6). In the production process, dangerous chemicals are processed using sophisticated machines. This process has potential dangers that can harm people, company property and the surrounding environment. The occurrence of work accidents can disrupt the company's productivity and even cause losses for the company, so management of potential dangers within the company must be carried out to prevent work accidents or health illnesses resulting from the implementation of work accidents. [1]–[4]. By looking at these potential dangers, occupational safety and health are necessary to prevent and reduce accidents at the phosphoric acid factory.

In dealing with work accidents in activities carried out at the phosphoric acid factory, risk management is needed to prevent accidents and minimise potential dangers, one of which is using steps for hazard identification, risk assessment and risk control (HIRARC). Risk management is a systematic approach to establishing the context, identifying, researching, assessing, treating, monitoring and communicating the risks associated with any activity, process or function, which can minimise business losses. [5]. At the hazard identification stage, the work safety analysis method is used, better known as JSA (Job Safety Analysis). Hazard identification is used to identify potential hazards in the work environment. Then in the second stage, risk assessment and control are carried out using the HIRARC (Hazard Identification, Risk Assessment and Risk Control) approach.

Therefore, to find out more about the potential for work accidents and their control in the scope of work, it is necessary to conduct a K3 risk analysis using the JSA and HIRARC methods.

Research Methods

This study was conducted at PT. Petrokimia Gresik, especially the phosphoric acid plant. This study aims to identify and analyse electrical hazards for occupational safety and health (K3). Primary data collection in this study was carried out through field observations and hazard identification. For secondary data in the form of dangerous documents K3 obtained from the company. The K3 risk analysis stage is performed using two methods, which are the Job Safety Analysis (JSA) method and the Hazard Identification, Risk Assessment and Risk Control (HIRARC) method.). Here is a situation that solves the problem:

JSA Method

Job Safety Analysis is a system used to determine potential hazards in each work activity as an effort to prevent work accidents [6]. JSA is the most important step in hazard risk analysis to ensure work safety. The application of JSA is carried out to identify potential dangers in every activity carried out at work so that workers are expected to be able to identify dangers before work accidents occur. [7]. In implementing the JSA method, 2 basic steps must be carried out, namely. [8]:

1. Determine the job being analysed
2. Identify hazards on each job

HIRARC Method

HIRARC is a concept in the risk management system that is used to reduce risk and minimise danger. Based on [9], HIRARC (Hazard Identification, Risk Assessment, and Risk Control) is one of the requirements in the K3 management system. It requires every organisation or company to prepare HIRARC to avoid potential dangers and serious impacts on workers. HIRARC could be a fundamental component within the world-related well-being security administration framework for anticipating and controlling dangers. HIRARC is a portion of the hazard administration framework (Risk Management) [10]. Hazard Identification, Risk Assessment and Risk Control or HIRARC is a system of elements in occupational safety and health efforts to prevent work accidents and control hazards. Based on OHSAS 18001:2007, the HIRARC concept is divided into three phases: hazard identification, risk assessment and risk control. This method can provide a risk assessment of the type of work carried out to determine how big the risk of danger will occur, minimise work accidents, and provide recommendations for controls to prevent work accidents. [11]–[13].

Hazard Identification

Risk recognisable proof could be a precise effort to distinguish potential risks within the work environment. Hazard identification aims to assist in deciding steps to make strides K3 within the company and preventive measures. [14]–[17]. Risk identification aims to identify as many sources of danger as possible and activities that pose a risk of harm. [11].

Risk Assessment

Risk assessment involves quantifying the risk level and its acceptability by evaluating the likelihood of an accident and the severity of its potential consequences. Risk assessment is essential because it can form an opinion about a risk. Risk assessment is carried out after all risks have been identified through risk analysis and evaluation. [18]. After eliminating or assessing the severity and frequency of accidents or illnesses that may arise, the level of risk for each hazard that has been identified can then be determined.[10], [19]–[21].

The point of chance investigation is to isolate minor passable dangers from significant dangers and to supply information to assess hazard appraisals. [22]. Risk analysis is carried out based on consideration of the source of risk, the consequences of the hazard and the possibility of identifying these consequences. Risk assessment is carried out based on AS/NZS 4360 of 1999. The risk assessment measurement consists of two parameters, namely consequences and likelihood [23]. Below is the risk assessment scale and its description:

Table 1. Probability Level Determination (Likelihood)

Levels	Descriptors	Description
A	Almost certain	This is expected to occur in most circumstances
B	Likely	This will probably occur in most circumstances
C	Possible	It might occur at some time
D	Unlikely	This could occur at some time
E	Rare	This may occur only in exceptional circumstances

(Source: AS/NZS 4360 (1999))

Table 2. Determination of Severity Level (Consequence)

Levels	Descriptors	Detailed Description
1	Insignificant	No injuries, low financial loss
2	Minor	First aid treatment, on-site immediately contained medium financial loss
3	Moderate	Required medical treatment, the on-site release contained with an outside assistant, high financial loss
4	Major	Extensive injuries, loss of production capability, off-side release with no detrimental effect, significant financial loss
5	Catastrophic	Death, toxic release off-side with detrimental effects, substantial financial loss

(Source: AS/NZS 4360 (1999))

From the two parameters above, the risk level can be determined with the risk categories below:

Table 3. Determination of Risk Level

Description		CONSEQUENCE				
		Insignificant	Minor	Moderate	Major	Catastrophic
LIKELIHOOD	Certain	H	H	E	E	E
	Likely	M	H	H	E	E
	Moderate	L	M	H	H	H
	Unlikely	L	L	M	M	H
	Rare	L	L	L	L	M

Information:

E (Extreme): Very High Risk

Activities should be stopped or suspended until the risk can be minimised. If the risk cannot be managed with the resources available, then the activity should not continue.

H (High): High Risk

Activities should be suspended or allowed to resume once the risks have been appropriately managed. It is necessary to reconsider the allocation of resources to reduce risks. If risks still exist during the execution of the work, action should be taken immediately.

M (Medium): Medium Risk

Efforts must be made to reduce risk, but they must be carefully considered and limited to the cost of the necessary precautions. Within a certain period, an evaluation of the risk reduction should be conducted.

L (Low): Risk Low

No additional control measures are required as the risks are acceptable. However, monitoring is still required to maintain and adequately implement controls.

To get the risk level value in the table above, the following equation is used:

Risk = Likelihood X Consequence

Risk Control

Risk control comes after the phases of hazard identification and risk assessment. Starting with the highest danger and working down to the lowest risk is how control is implemented in this study. With a focus on all viable solutions that align with the company's actual circumstances, this strategy seeks to prevent and manage risks as best as possible. [24]. This can involve putting security and safety policies into action, using personal protective equipment (PPE), educating staff, and closely monitoring projects as they are carried out. [25].

Results and Discussion

Hazard Identification

Research: This made observation and identification of danger to safety and health work at a factory job involving phosphoric acid. At this stage, the focus is identifying potential dangers in the environment, work, or the work process. [26]. Based on observations that have been made, obtained information that there are several types of work, including:

Table 4. Hazard Identification

No	Type of Work	Identification Danger	Risk
1	Loading Phosphate Rock	Easy ingredients burnt	Fatalities Losses 1 M - 10 M
2	Loading Antifoam	**Physical** Slip spill **Environmental** Slippery area	**Human** MTI
3	Control Area Handling	**Physically** Pinned **Physical** Tripping Exposure to Irritant Materials phosphate rock dust	**Human** LTI **Human** MTI **Human** Disorders health chronic
4	Control Area Grinding	**Physical** Noise **Chemical** Exposure to phosphate rock dust	**Human** Disruption health chronic **Human** Disruption health chronic
5	Control Area Fluorine System	**Chemical** Exposure to fluorine gas Doused/splashed sour fluosilicate	**Human** MTI, Disorder health I
6	Control Area Reaction	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate **Physical** Noisy **Physical** Pinned	**Human** LTI, Interference Health I **Human** Disruption health chronic **Human** LTI
7	Control Area Concentration	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate **Physical** Noisy	**Human** LTI, Interference Health I **Human** Disruption health chronic
8	Check Density Reaction Units	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** MTI Disorder health I
9	Check Fluorine Density and Concentration	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** MTI Disorder health I
10	Flushing Spray Acid / Spray Cloth	**Chemical**	**Human**

No	Type of Work	Identification Danger	Risk
		Exposure to fluorine gas	MTI
		Doused/splashed sour phosphate	Disorder health I
11	Cleaning Line	**Physical** Falls	**Human** Fatalities
		Physical Fall	**Human** Fatalities
		Chemical Corrosive materials	**Human** LTI
12	Sour Drain Line Sulfate	**Chemical** Fluids corrosive	**Human** Fatalities

Furthermore, the hazard identification obtained includes several types of hazards, including:

1) Physical: noise, vibration, electricity, ultraviolet light, explosion, extreme temperatures, drops/falls, slips, trips, falls, etc.
2) Mechanical: lifting equipment, vehicle, welding equipment, rotating equipment, cutting equipment, pneumatic, hydraulic, sharp object, etc.
3) Chemical: explosive materials, flammable materials, oxidising agents, pressurised, reactive materials, poisonous materials, environmentally damaging materials, corrosive materials, etc.
4) Environmental: lighting, working at height, working in a confined space (limited space), slippery, moist, extreme weather, sea wave, earthquake, other.
5) Ergonomics: work tools, way of work, workplace, repetitive work, lifting heavy loads, others.

Risk Assessment

Risk evaluation is done to determine the level of risks that have been done after identifying danger with a review of table level severity and table level possible and already assessed based on table determination level risk based on later company data results from level risk evaluated for determining criteria risk.

Table 5. Risk Assessment

No	Type of Work	Identification Danger	Risk	L	C	S	Risk Level
1	Loading Phosphate Rock	Easy ingredients burnt	Fatalities	3	5	15	High
			Losses 1 M - 10 M	3	4	12	Medium
2	Loading Antifoam	**Physical** Slip spill **Environmental** Slippery area	**Human** MTI	3	3	9	High
3	Control Area Handling	**Physically** Pinned	**Human** LTI	2	4	8	Medium
		Physical Tripping	**Human** MTI	4	3	12	High
		Exposure to Irritant Materials phosphate rock dust	**Human** Disorders health chronic	4	4	16	Extreme
4	Control Area Grinding	**Physical** Noise	**Human** Disruption health chronic	5	4	20	Extreme
		Chemical Exposure to phosphate rock dust	**Human** Disruption health chronic	4	4	16	Extreme
5	Control Area Fluorine System	**Chemical** Exposure to fluorine gas Doused/splashed sour fluosilicate	**Human** MTI, Disorder health I	3	3	9	High
6		**Chemical**	**Human**	3	4	12	High

	Control Area Reaction	Exposure to fluorine gas Doused/splashed sour phosphate	LTI, Interference Health I				
		Physical Noisy	**Human** Disruption health chronic	3	4	12	High
		Physical Pinned	**Human** LTI	4	4	16	Extreme
7	Control Area Concentration	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** LTI, Interference Health I	3	4	12	High
		Physical Noisy	**Human** Disruption health chronic	3	4	12	High
8	Check Density Reaction Units	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** MTI Disorder health I	3	3	9	High
9	Check Fluorine Density and Concentration	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** MTI Disorder health I	3	3	9	High
10	Flushing Spray Acid / Spray Cloth	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** MTI Disorder health I	3	3	9	High
11	Cleaning Line	**Physical** Falls	**Human** Fatalities	3	5	15	High
		Physical Fall	**Human** Fatalities	3	5	15	High
		Chemical Corrosive materials	**Human** LTI	3	4	12	High
12	Sour Drain Line Sulfate	**Chemical** Fluids corrosive	**Human** Fatalities	3	5	15	High

Risk Control

Risk control measures based on HIRARC have an essential role in reducing the real impact of work accident risks and reducing the level of risk in HIRARC by considering the basic hierarchy of control, namely elimination, substitution, technical engineering, administration and personal protective equipment (PPE) by adjusting conditions in the work field. The controls carried out in this research are based on a risk control hierarchy that has gone through the process of hazard identification, risk assessment and control and has been taken into consideration according to field conditions, namely technical engineering, administration and personal protective equipment. The risk control table is below.

Table 6. Risk Control

No	Type of work	Identification Danger	Risk	L	C	S	Risk Level	Existing Control
1	Loading Phosphate Rock	Easy ingredients burnt	Fatalities	3	5	C	High	Flashback arrestor installation, making a safety permit
			Losses 1 M - 10 M	3	4	12	Medium	
2	Loading Antifoam	**Physical** Slip spill	**Human** Medical Treatment Injury	3	3	9	High	**Elimination**: Cleaning area from antifoam spill

		Environmental Slippery area						**Administration**: Work according to SOP, installation of slippery road warning signs **APD**: Use of area-appropriate PPE (gloves and rubber shoes)
3	Control Area Handling	**Physically** Pinned	**Human** Lost Time Injury	2	4	8	Medium	**Engineering**: pull cord **Administration**: Working according to SOP, installation of pinched warning signs
		Physical Tripping	**Human** Medical Treatment Injury	4	3	12	High	
		Exposure to **Irritant Materials** phosphate rock dust	**Human** Disorders health chronic	4	4	16	Extreme	
4	Control Area Grinding	**Physical** Noise	**Human** Disruption health chronic	5	4	20	Extreme	**Administration**: Working according to SOP, installation of noise exposure hazard signs, installation of NAB signs, noise **APD**: Use of area-appropriate APD (earmuff)
		Chemical Exposure to phosphate rock dust	**Human** Disruption health chronic	4	4	16	Extreme	
5	Control Area Fluorine System	**Chemical** Exposure to fluorine gas Doused/splashed sour fluosilicate	**Human** Medical Treatment Injure, Disorder health	3	3	9	High	**Administration**: Installation of hazard signs for exposure to phosphate rock dust **APD**: Use of area-appropriate PPE (dust mask and goggles)
6	Control Area Reaction	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** Last Time Injure, Interference Health.	3	4	12	High	**Administration**: Work according to SOP, installation of noise exposure hazard signs, installation of Noise NAB signs **APD**: Use of area-appropriate PPE (earmuff)
		Physical Noisy	**Human** Disruption health chronic	3	4	12	High	
		Physical Pinned	**Human** Last Time Injure,	4	4	16	Extreme	

			Interference health					
7	Control Area Concentration	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** Last Time Injure, Interference Health.	3	4	12	High	**Administration**: Installation of hazard signs for exposure to phosphate rock dust **APD**: Use of area-appropriate PPE (dust mask and goggles)
		Physical Noisy	**Human** Disruption health chronic	3	4	12	High	
8	Check Density Reaction Units	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** Medical Treatment Injury Disorder health	3	3	9	High	**Engineering**: Break the flow of equipment and drain the remaining fluid **Administration**: Work according to SOP, Installation of hazards of exposure to acid chemicals **APD**: Use of area-appropriate PPE (goggles, gas masks and safety shoes)
9	Check Fluorine Density and Concentration	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** Medical Treatment Injury Disorder health	3	3	9	High	**Engineering**: Cut off the flow in the equipment and drain the remaining fluid **Administration**: Work according to SOP, installation of hazards of exposure to acid chemicals **APD**: Use of area-appropriate PPE (goggles, gas masks and safety shoes)
10	Flushing Spray Acid / Spray Cloth	**Chemical** Exposure to fluorine gas Doused/splashed sour phosphate	**Human** Medical Treatment Injury Disorder health	3	3	9	High	**Administration**: Work according to SOP, installation of noise, exposure hazard signs, installation of Noise, NAB signs **APD**: Use of area-appropriate PPE (earmuff)

11	Cleaning Line	**Physical** Falls	**Human** Fatalities	3	5	15	High	**Engineering**: Installing scaffolding according to standards **Administration**: Making safety permits, ensuring usable scaffolding with wearable tags **APD**: Use of area-appropriate APD (safety helmet and safety shoes, full body harness)
		Physical Fall	**Human** Fatalities	3	5	15	High	
		Chemical Corrosive materials	**Human** Last Time Injure	3	4	12	High	
12	Sour drain line sulphate	**Chemical** Fluids corrosive	**Human** Fatalities	3	5	15	High	**APD**: Using APD Acid suit **Engineering**: Blocking line **Administration**: Safety permit, working according to SOP, installing safety tags, barricading

Conclusion

It was considering studies conducted on labour near phosphoric acid factories at PT. Petrokimia Gresik concluded that risk identification using the JSA method found several dangers that emerged, including the first if workers did not use appropriate personal protective equipment (PPE), the second was danger from work environmental factors such as work in areas in direct contact with chemicals and work. In the high-altitude area, the third did not work according to the SOP that was in effect at the company. In the meantime, drawing from the outcomes of the risk evaluation conducted through the HIRARC approach obtained from 21 total risks in all jobs, the extreme risk was four risks (19%), the high risk was 15 risks (71.5), the medium risk was two risks (9.5%) and not getting a job with a low level of risk. The implemented control strategy in this study involves employing elimination, engineering solutions, administrative measures, and personal protective equipment (PPE) to manage risks.

References

[1] F.Novianti, A.Windriya, U.Diponegoro, andU.Diponegoro, “Hazard Analysis of Occupational Health and Ssfety (OHS) Using The JSA (Job Safety Analysis) Method in Grey Weaving 2 Warehouse PT,” vol. 2, no. 1, pp. 33–47, 2023.

[2] M.Nur, “Analisis Keselamatan dan Kesehatan Kerja Menggunakan Metode Hazard And Operability Study (HAZOP) Di PT. XYZ,” *J. Tek. Ind*, vol. 4, no. 2, 2018.

[3] M.Jufriyanto, “Analisis Keselamatan Dan Kesehatan Kerja Dengan Metode Hazard And Operability (Hazop) Pada Workshop PT. Petrogas Jatim Utama,” *J. Tek. Ind. J. Has. Penelit. dan Karya Ilm. dalam Bid. Tek. Ind.*, vol. 9, no. 2, pp. 472–480.

[4] M.Nur, “Analisis Keselamatan dan Kesehatan Kerja Menggunakan Metode Hazard And Operability Study (HAZOP) Di PT. XYZ,” *J. Tek. Ind. J. Has. Penelit. dan Karya Ilm. dalam Bid. Tek. Ind.*, vol. 4, no. 2, p. 133, 2020, doi: 10.24014/jti.v4i2.6627.

[5] K.Afriani, “Manajemen Risiko Kesehatan Dan Keselamatan Kerja Pada Pekerja Industri Kapal Pinisi Di Kelurahan Tanah Lemo Kecamatan Bontobahari Kabupaten Bulukumba,” 2021.

[6] W. F.Supriyadi, T. S. P.Arifin, andF. N.Abdi, "Jurnal Ilmu Pengetahuan dan teknologi sipil Analisis Risiko K3 Menggunakan Pendekatan Hiradc Dan Metode JSA (Studi Kasus : Proyek Pembangunan Gedung Bpkad Samarinda) Abstrak Jurnal Ilmu Pengetahuan dan teknologi sipil," pp. 72–81.

[7] P.Studi *et al.*, "Identifikasi Dan Analisis Risiko Kecelakaan Kerja Dengan Metode JSA (JOB Safety Analysis) Di Bengkel Pemesinan Smk Nurul Islam Gresik," vol. 20, no. 1, pp. 300–307, 2022.

[8] W. R.Rizkullah, H. C.Suroso, andA.Wijaya, "Analisis Resiko Bahaya di Plat Cair 1 Menggunakan Metode JSA (Job Safety Analysis) dan Fine," no. Senastitan Iv, pp. 1–6, 2024.

[9] OHSAS 18002, *Persyaratan Sistem Manajemen K3*. OHSAS Project Group, 2008.

[10] S.Ramli, *Sistem Manajemen Keselamatan dan Kesehatan Kerja OHSAS 18001*. PT. Dian Rakyat, 2010.

[11] B. F.Aprilla andD.Yulhendra, "Penerapan Metode HIRARC dalam Menganalisis Risiko Bahaya dan Upaya Pengendalian Kecelakaan Kerja di Area Crusher dan Belt Conveyor PT . Semen Padang," vol. 8, no. 1, pp. 203–212.

[12] M.Nur, V.Valentino, R. K.Sari, andA. A.Karim, "Analisa Potensi Bahaya Kecelakaan Kerja Terhadap Pekerja Menggunakan Metode Hazard Identification, Risk Assement And Risk Control (HIRARC) Pada Perusahaan Aspal Beton," *J. Teknol. Dan Manaj. Ind. Terap.*, vol. 2, no. 3, pp. 150–158, 2023.

[13] M.Siska andM.Gassani, "Analisis 5s dan Hirarc Pada Stasiun Kerja Rotary, Dryer dan Veneer Compouser di PT. Asia Forestama Raya Pekanbaru," *J. Tek. Ind.*, vol. 4, no. 1, 2018.

[14] F.Yuamita, "Analisis Risiko Potensi Kecelakaan Kerja Pada Pekerja Departemen Persiapan Produksi Menggunakan Metode HIRADC (Hazard Identification, Risk Assesment And …," *J. Teknol. dan Manaj. Ind. Terap.*, 2023, [Online]. Available: http://jurnal-tmit.com/index.php/home/article/view/63

[15] M. A.Pratama, A. W.Rizqi, andH.Hidayat, "Analisis Resiko K3 Pada Pekerjaan Fabrikasi Konstruksi Di Cv. Arfa Putra Karya Dengan Metode Jsa (Job Safety Analysis)," *J. Tek. Ind. J. Has. Penelit. dan Karya Ilm. dalam Bid. Tek. Ind.*, vol. 8, no. 2, pp. 314–323, 2022.

[16] I.Rahmanto andM. I.Hamdy, "Analisa Resiko Kecelakaan Kerja Karyawan Menggunakan Metode Hazard and Operability (HAZOP) di PT PJB Services PLTU Tembilahan," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, no. II, pp. 53–60, 2022.

[17] M. A.Wagiman andF.Yuamita, "Analisis Tingkat Risiko Bahaya Kerja Menggunakan Metode Hazop (Hazard And Operability) Pada PT Madubaru PG/PS Madukismo.," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, no. 4, pp. 277–285, 2022.

[18] R. P.Khoiri, R. D.Atmajayani, andT.Widodo, "Occupational Health And Safety (K3) Risk Analysis Using Hiradc And Jsa Methods In," vol. 4, no. 2, pp. 195–210, 2023.

[19] S. S.Arnau, "Musculoskeletal disorders risk assessment methods: a scoping review from a sex perspective," *Ergonomics*. 2023. doi: 10.1080/00140139.2023.2168767.

[20] P. J.Beliveau, "Musculoskeletal disorder risk assessment tool use: A Canadian perspective," *Appl. Ergon.*, vol. 102, 2022, doi: 10.1016/j.apergo.2022.103740.

[21] S.Veerasammy, "Multi-task exposure assessment to infer musculoskeletal disorder risk: A scoping review of injury causation theories and tools available to assess exposures," *Applied Ergonomics*, vol. 102. 2022. doi: 10.1016/j.apergo.2022.103766.

[22] AS/NZS 4360, *Risk Management*. 1999.

[23] J. T.Industri, S.Medan, I. R.Assesment, andK.Kerja, "Analisis Resiko Kecelakaan Kerja di CV . Jati Jepara Furniture dengan Metode HIRARC (Hazard Identification Risk Assessment and Risk Control) Lamhot Willy Afredo *, Uni Pratama Pebrina Br Tarigan," vol. 4, no. 2, 2021.

[24] M. I.Hamdani andD.Andesta, "G-Tech : Jurnal Teknologi Terapan," vol. 8, no. 2, pp. 887–895, 2024.

[25] D. E.Wibowo, I.Wahyuni, A. D.Hastutiningsih, I. M.Nurshefa, andD. D.Rimbawati, "Occupational safety and health risk analysis using HIRARC and JSA methods in building projects construction," no. August, 2023, doi: 10.1063/5.0128851.

[26] D. I.Pabrik, K.Tempe, A. R.Afillah, F.Handoko, andH.Galuh, "Penggunaan Metode Jsa Untuk K3 Sebagai Pengendalian Risiko Kecelakaan Kerja (Studi Kasus Pada Industri Keripik Tempe Andra)," vol. 6, no. 2, pp. 237–244, 2023.