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Hazard Identification and Risk Control Using the HIRADC Method at the Paper Plant of PT XYZ

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Abstract
Paper-processing plants involve complex and multidimensional hazards, including physical, chemical, mechanical, electrical, and ergonomic hazards, that require systematic occupational health and safety (OHS) management. This study aimed to identify hazards, assess risk levels, and determine appropriate risk controls in the Paper Plant area of PT Trigunapratama Abadi using the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method referring to the AS/NZS 4360:2004 standard. Data were collected through field observation, semi-structured interviews with the HSE Division officers and plant operators, and document review, then analyzed using a likelihood × severity risk matrix. The results identified 23 potential hazards spread across 10 main work activities and one plant-wide hazard group, with physical hazards (39.1%) being the most dominant, followed by mechanical (17.4%) and chemical (13.0%) hazards. Before control measures, 6 hazards (26.1%) fell into the Substantial category (score 10-12) and 17 hazards (73.9%) into the Moderate category (score 6-9), with none in the Low or High/Extreme categories. After recommended controls based on the hierarchy of hazard control engineering controls, administrative controls, and personal protective equipment 6 hazards (69.6%) were reduced to the Low category and 7 hazards (30.4%) remained Moderate, with all Substantial and High/Extreme risks eliminated.
Keywords: *HIRADC, hazard identification, risk assessment, paper plant, occupational health and safety*

Abstrak
Area produksi kertas memiliki karakteristik bahaya yang kompleks dan multidimensi, meliputi bahaya fisik, kimia, mekanik, listrik, dan ergonomi, sehingga memerlukan pengelolaan Keselamatan dan Kesehatan Kerja (K3) yang sistematis. Penelitian ini bertujuan untuk mengidentifikasi bahaya, menilai tingkat risiko, dan menentukan langkah pengendalian yang tepat di area Plant Kertas PT Trigunapratama Abadi menggunakan metode *Hazard Identification, Risk Assessment, and Determining Control* (HIRADC) yang mengacu pada standar AS/NZS 4360:2004. Data dikumpulkan melalui observasi lapangan, wawancara semi-terstruktur dengan petugas Divisi HSE-K3 dan operator, serta studi dokumentasi, kemudian dianalisis menggunakan matriks risiko likelihood × severity. Hasil penelitian menemukan 23 potensi bahaya yang tersebar pada 10 aktivitas kerja utama dan satu kelompok bahaya yang mencakup seluruh area plant, dengan bahaya fisik (39,1%) sebagai jenis bahaya paling dominan, diikuti bahaya mekanik (17,4%) dan kimia (13,0%). Sebelum pengendalian, 6 bahaya (26,1%) berkategori Substantial (skor 10-12) dan 17 bahaya (73,9%) berkategori Moderate (skor 6-9), tanpa ada bahaya berkategori Low maupun High/Extreme. Setelah diterapkan langkah pengendalian berdasarkan hirarki pengendalian risiko K3 rekayasa teknik, pengendalian administratif, dan alat pelindung diri sebanyak 16 bahaya (69,6%) berhasil diturunkan ke kategori Low dan 7 bahaya (30,4%) tersisa pada kategori Moderate, tanpa ada lagi bahaya berkategori Substantial maupun High/Extreme.
Kata Kunci: *HIRADC, identifikasi bahaya, penilaian risiko, plant kertas, keselamatan dan kesehatan kerja*

1. Introduction

Occupational Safety and Health (OSH) is a fundamental aspect of industrial operations management aimed at protecting workers from workplace hazards. The International Labor Organization (ILO) reports that approximately 2.78 million workers die each year as a result of work-related accidents or illnesses. At the national level, data from the Social Security Administration for Employment (BPJS Ketenagakerjaan) shows a rising trend in workplace accidents, from 221,740 cases in 2020 to 462,241 cases in 2024, according to the Indonesian Ministry of Manpower. This trend is influenced by weak OSH management, low workplace safety literacy, and suboptimal government oversight [1].

Regulatory-wise, Indonesia already has a strong legal framework in the field of occupational safety and health (OSH), including Law No. 1 of 1970 on Occupational Safety [2] and Government Regulation No. 50 of 2012 on the Implementation of the Occupational Safety and Health Management System (SMK3) [3]. The international standard ISO 45001:2018 also emphasizes the obligation of organizations to proactively identify hazards, assess risks, and establish appropriate controls. The OSH risk assessment in this study refers to the AS/NZS 4360:2004 standard, which provides a quantitative risk assessment matrix framework based on a combination of likelihood and severity values, so that each potential hazard can be categorized and prioritized for handling objectively .

The manufacturing sector, including the paper processing industry, is one of the sectors with a high risk of workplace accidents. The work environment in paper production areas is characterized by complex and multidimensional hazards, including physical hazards such as machine noise exceeding threshold limits, exposure to high temperatures, and vibrations; chemical hazards in the form of exposure to paper fiber dust and chemical vapors; mechanical hazards resulting from the operation of rotating machinery; and ergonomic hazards resulting from prolonged work postures that do not meet standards [4]. Gaps between regulations and actual on-site practices are still frequently observed; a reactive OSH approach where actions are taken only after an accident occurs still dominates risk management in many Indonesian manufacturing companies [5]. The success of OSH implementation depends heavily on the quality of the hazard identification process conducted before an accident occurs not after thereby reinforcing the urgency of a proactive, data-driven approach to hazard identification [6].

One internationally recognized method in occupational safety and health (OSH) risk management is Hazard Identification, Risk Assessment, and Determining Control (HIRADC), which operates systematically through three main stages: hazard identification, risk assessment based on a combination of likelihood and severity, and the determination of control measures based on the hierarchy of risk control. The implementation of HIRADC has been proven to reduce hazard risk categories from high to low after hierarchy-based controls are implemented [5], and it allows companies to objectively prioritize control measures based on measurable risk values, unlike conventional inspection approaches [6].

PT Trigunapratama Abadi is a company engaged in the management of Hazardous and Toxic Waste (B3), with one of its primary operational areas being the Paper Plant, which processes paper sludge into low-grade paper products. Based on initial observations conducted during the internship at the HSE-K3 Division, it was found that risk management in the Paper Plant area is not yet fully supported by comprehensive and standardized HIRADC documents, resulting in various potential physical, chemical, mechanical, electrical, and ergonomic hazards not being fully identified and systematically documented. Therefore, this study aims to (1) identify potential hazards in the Paper Plant area, (2) assess the risk level of each identified hazard based on a likelihood × severity matrix, and (3) determine appropriate and standardized risk control measures based on the OSH risk control hierarchy, as a tangible contribution to supporting the company's compliance with the obligations mandated by Government Regulation No. 50 of 2012 and ISO 45001:2018.

2. Material and Methods

This study applied the HIRADC method at the PT Trigunapratama Abadi Paper Plant, a hazardous waste management company located in Karawang Regency, West Java. This area was selected because it presents complex hazards, including physical, chemical, mechanical, electrical, and ergonomic hazards. The study was conducted at the HSE-K3 Division over the course of one month, with students directly participating in field observations, completing K3 documentation, and engaging in technical discussions with the HSE-K3 team.

The data used consisted of primary data namely, results from direct observations, interviews, and hazard identification forms as well as secondary data in the form of safe work procedure documents (SOPs), OSH inspection and audit reports, historical workplace accident data, and relevant OSH regulations. Data collection was conducted using four techniques: a literature review of scientific journals and international standards (ISO 45001:2018 and AS/NZS 4360:2004); a field study involving systematic observation of all work activities at the Paper Plant; semi-structured interviews with HSE-K3 Division staff and field operators; and documentation of existing SOPs, inspection records, and incident reports.

Data processing is performed by entering all potential hazards into the HIRADC form, grouped by activity type and hazard type (physical, chemical, mechanical, electrical, and ergonomic), and then assessing the risk level using a likelihood × severity matrix according to Equation (1) below:

$$R = L \times S \qquad (1)$$

where R represents the risk value, L represents the likelihood of a hazard occurring on a scale from 1 (Rare) to 5 (Almost Certain), and S represents the severity of the impact on a scale from 1 (Insignificant) to 5 (Catastrophic). The resulting risk score ranges from 1 to 25 and is categorized into four levels based on the AS/NZS 4360:2004 standard: Low (score 1-4), Moderate (score 5-9), Substantial (score 10-16), and High/Extreme (score 17-25).

Based on the risk categories identified, control measures are established in accordance with the hierarchy of occupational safety and health (OSH) risk control principles, in the following order:

1. Elimination, which involves completely removing the hazard
2. Substitution, which involves replacing the hazard source with a safer alternative;
3. Engineering controls, which involve modifying the design of the work environment or equipment;
4. Administrative controls, in the form of procedures, rules, and training;
5. Personal protective equipment (PPE) as the last line of defense.

Hazards in the highest-risk category are given the highest priority for control, and all results of hazard identification, risk assessment, and control determination are documented in the HIRADC form as the primary output of the study.

3. Results and Discussion

Overview of the Research Subject

PT Trigunapratama Abadi is a company engaged in the management of Hazardous and Toxic (B3) waste, including the transportation, treatment, and utilization of waste, and has been operating since 1989 in Karawang Regency, West Java. One form of waste utilization carried out by the company is the production of from paper sludge waste at the Paper Plant. The company has obtained ISO 9001:2015, ISO 14001:2015, and ISO 45001:2018 certifications, and implements an Occupational Safety and Health Management System (SMK3). Occupational Safety and Health (OSH) management in the Paper Plant area falls under the supervision of the HSE-OSH Division, which is responsible for hazard identification, risk assessment, the preparation of OSH documentation, and oversight of the use of personal protective equipment (PPE) throughout all operational areas. Hazard Identification.

Based on field observations, interviews, and documentation of 10 key work activities in the Paper Plant area including hazardous waste (B3) reception, paper sludge storage, the Oval Tank process, Paper Making, Oven, Roll Machine, Cutting Roll and Cut Sheet, Ball Press, handling of rejected paper, as well as product labeling and storage successfully identified 23 potential hazards, including one group of fire and electrical hazards that covers the entire plant area. The classification of hazard types based on the identification results is presented in **Table 1**.

Table 1. Classification of Hazard Types in the Paper Plant Area

No	Hazard Type	Hazard Number	Quantity	Percentage
1	Physics	3. 5. 6. 8. 10. 11. 16. 22	8	34.8%
2	Mechanics	7. 13. 15. 17	4	17.4%
3	Chemistry	2. 4. 9	3	13.0%
4	Physics & Ergonomics	19. 20	2	8.7%
5	Ergonomics	18. 21	2	8.7%
6	Electrical Engineering	12. 23	2	8.7%
7	Physics & Mechanics	1	1	4.3%
8	Physics (noise/vibration)	14	1	4.3%
	Total		23	100%

Based on **Table 1**, physical hazards are the most prevalent type of hazard, accounting for 8 hazards (34.8%) spread across nearly all stages of the production process from storage, the Oval Tank process, the oven, and the cutting roll, to the risk of fire throughout the plant. Mechanical hazards rank second with 4 hazards (17.4%), all of which are related to rotating machine components in the paper-making process, roll machines, cutting rolls, and press balls. Chemical hazards were identified in 3 instances (13.0%) related to exposure to B3 paper sludge and paper fiber dust, while ergonomic, electrical, and combined physical-mechanical and physical-ergonomic hazards were each found in smaller numbers. These characteristics are

consistent with findings in other processing industries, which are also dominated by physical and mechanical hazards resulting from the use of rotating production machinery [7], [8].

Risk Assessment and Determination of Controls

Each identified hazard is then assessed for risk level using a likelihood × severity matrix, after which control measures are established based on the OHS risk control hierarchy. The complete results of the hazard identification, risk assessments before and after controls, and control recommendations are presented in Table 2.

Table 2. Results of Hazard Identification, Risk Assessment, and Control Selection (HIRADC) at the PT Trigunapratama Abadi Paper Plant

No	Work Activity	Hazard Source	Type	Potential Accident	L	S	R	Level	Control Measures	L	S	R	Level
1	Receipt of Hazardous Waste (Paper Sludge)	Vehicles transporting paper sludge and related materials	Physical & Mechanical	Struck by materials; run over by vehicles	2	3	6	Moderate	Administrative: SOPs for loading and unloading, warning signs. PPE: helmet, safety shoes, gloves.	2	2	4	Low
2	Receipt of Hazardous Waste (Paper Sludge)	Paper sludge (hazardous waste)	Chemical	Skin/eye irritation; health hazards	3	3	9	Moderate	Engineering controls: Enclose the receiving area. Administrative controls: Hazardous waste SOP. PPE: rubber gloves, goggles, mask.	2	2	4	Low
3	Sludge Paper Storage at Plant 1	et/damp floor in storage area	Physical	Slip	3	2	6	Moderate	Engineering: non-slip flooring. Administrative: routine cleaning schedule. PPE: non-slip safety shoes.	2	2	4	Low
4	Sludge Paper Storage at Plant 1	Piles of sludge paper	Chemical	Respiratory irritation	3	3	9	Moderate	Engineering controls: ventilate the storage area. Administrative controls: limit exposure time. PPE: N95 respirator.	2	2	4	Low
5	Oval Tank Process (Mixing)	The oval tank contains a mixture of sludge and water	Physical	Fall; drowning/serious injury	3	3	9	Moderate	Engineering: safety railings, tank cover. Administrative: operating SOP. PPE: harness.	2	2	4	Low
6	Oval Tank Process (Mixing)	Wet floor in the oval tank area	Physical	Slip	3	2	6	Moderate	Engineering: non-slip flooring, drainage. Administrative: area cleaning procedures. PPE: non-slip safety shoes.	2	2	4	Low
7	Paper-Making Process (Paper-Making Machine)	Rotating paper-making machine	Mechanical	Pinched, pulled, crushed	3	3	9	Moderate	Engineering controls: machine guards, interlocks. Administrative controls: operating SOPs. PPE: gloves, safety shoes.	2	2	4	Low

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No	Work Activity	Hazard Source	Type	Potential Accident	L	S	R	Level	Control Measures	L	S	R	Level
8	Paper-Making Process (Paper-Making Machine)	Paper-making machine (noise)	Physical	Permanent hearing loss	3	3	9	Moderate	Engineering controls: noise dampeners, separate panel rooms. Administrative controls: job rotation, periodic measurements. PPE: earplugs/earmuffs.	3	2	6	Moderate
9	Paper Manufacturing Process (Paper-Making Machine)	Paper fiber dust from the production process	Chemical	Respiratory disorders (acute respiratory infections, occupational asthma)	2	3	6	Moderate	Engineering controls: dust collector, ventilation. Administrative controls: periodic dust level measurements. PPE: N95 respirator mask.	2	2	4	Low
10	Oven Process (Paper Drying)	High-temperature oven	Physical	Burns/injuries from contact with hot surfaces	3	3	9	Moderate	Engineering controls: thermal insulation, protective covers. Administrative controls: SOPs, warning signs. PPE: heat-resistant gloves, apron.	2	2	4	Low
11	Oven Process (Paper Drying)	Exposure to high temperatures in the oven area	Physical	Dehydration and heat stress	3	2	6	Moderate	Engineering controls: fans/air conditioning. Administrative controls: work rotation, drinking water. PPE: heat-resistant clothing.	2	2	4	Low
12	Oven Process (Paper Drying)	Electrical Installation of the Oven	Electricity	Electric Shock	2	5	10	Substantial	Engineering: grounding, ELCB/RCD protection. Administrative: periodic electrical inspections. PPE: insulated gloves.	2	3	6	Moderate
13	Rolling Machine Process	Rotating machine roller components	Mechanical	Pinch/pull injuries, hand/finger injuries	3	4	12	Substantial	Engineering: machine guards, safety sensors, emergency stop. Administrative: SOPs, occupational safety and health training. PPE: special gloves, safety shoes.	2	3	6	Moderate
14	Rolling Mill Process	Rolling mill in operation	Physical	Hearing loss; HAVS	3	3	9	Moderate	Engineering controls: vibration isolation, noise attenuation. Administrative controls: job rotation, vibration monitoring. PPE: earplugs, anti-vibration gloves.	2	2	4	Low

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No	Work Activity	Hazard Source	Type	Potential Accident	L	S	R	Level	Control Measures	L	S	R	Level
15	Roll and Sheet Cutting Process	Sharp cutting machine blades	Mechanical	Cuts/injuries	3	4	12	Substantial	Engineering: blade guards, interlocking systems. Administrative: SOPs, occupational safety and health training. PPE: cut-resistant gloves, safety glasses.	2	3	6	Moderate
16	Roll Cutting & Sheet Cutting Process	Sharp edges of cut paper sheets	Physical	Cut	2	3	6	Moderate	Administrative: SOP for handling cut materials, training. PPE: cut-resistant gloves.	2	2	4	Low
17	Ball Pressing Process (Small)	Hydraulic ball press machine	Mechanical	inch; crush injury to the hand	3	4	12	Substantial	Engineering controls: two-hand control, safety sensors, safety guard. Administrative controls: SOPs, occupational safety and health training. PPE: gloves, safety shoes.	2	3	6	Moderate
18	Ball Pressing Process (Small)	Paper positioning tasks	Ergonomics	Musculoskeletal disorders (MSDs)	3	3	9	Moderate	Engineering: adjustable workbench, assistive jigs. Administrative: job rotation, ergonomics training. PPE: back support belt.	2	2	4	Low
19	Handling of Rejected Paper	Rejected paper that is discarded or returned	Physical & Ergonomic	Cuts; musculoskeletal injuries	2	3	6	Moderate	Administrative: SOPs for handling, proper lifting techniques. PPE: gloves, safety shoes, back support belt.	2	2	4	Low
20	Labeling & Product Storage	Stacks of finished paper products	Physical & Ergonomic	actors Being struck by products; back injuries	3	3	9	Moderate	Engineering: stable storage racks, hand trucks/forklifts. Administrative: SOPs, stack height limits. PPE: gloves, safety shoes.	2	2	4	Low
21	Labeling & Product Storage	Product shelving	Ergonomics	usculoskeletal disorders	3	2	6	Moderate	Engineering: appropriately sized shelves, shelving aids. Administrative: job rotation, ergonomics training. PPE: back support belt.	2	2	4	Low
22	Entire Paper Plant Area	Paper and paper sludge are flammable	Physical	Fire	3	4	12	Substantial	Engineering: Fire extinguishers, hydrants, smoke detectors. Administrative: Emergency response SOPs, fire extinguisher training. PPE: Fire	2	2	4	Low

No	Work Activity	Hazard Source	Type	Potential Accident	L	S	R	Level	Control Measures	L	S	R	Level
									extinguishers, fire blankets.				
23	Entire Paper Plant Area	Electrical Installations in the Plant Area	Electrical	Electrical Accidents	2	5	10	Substantial	Engineering: periodic inspections and maintenance, MCB/ELCB protection. Administrative: no touching of panels, certified personnel. PPE: insulated gloves.	2	3	6	Moderate

Based on **Table 2**, prior to the implementation of control measures, there were 6 hazards (26.1%) classified as "Substantial" with risk scores of 10-12, namely electric shock from the oven machinery (R=10), being pinched by the roller components of the roll machine (R=12), being cut by the blades of the cutting roll and cut sheet machines (R=12), being pinched by the ball press machine (R=12), fire risk throughout the Paper Plant area (R=12), and electrical accidents in the plant's electrical installations (R=10). The high risk scores for these six hazards were due to high severity values, given that their potential impacts include serious injury, permanent disability, or even death if not properly controlled. A total of 17 other hazards (73.9%) fell into the Moderate category with scores of 6-9, and no hazards were found in the Low or High/Extreme categories prior to control measures, as summarized in **Table 3**.

Table 3. Summary of Risk Levels Before Control Measures

Risk Level	Number of Hazards	Percentage
High/Extreme (17-25)	0	0%
Substantial (10-16)	6	26.1%
Moderate (5-9)	17	73.9%
Low (1-4)	0	0%
Total	23	100%

The recommended control measures follow the OSH risk control hierarchy, with priority given to engineering controls for hazards categorized as "Substantial," such as the installation of machine guards, safety sensors, and emergency stop buttons on the Roll Machine, Cutting Roll, and Ball Press; ELCB/RCD protection systems in the electrical installations of the Oven and throughout the plant; and the installation of fire extinguishers, fire hydrants, and smoke detectors to address fire risks. These controls are supplemented by administrative controls in the form of SOPs and OSH training, as well as the use of PPE as the last line of defense.

Following the implementation of control measures, there was a significant reduction in the risk level for all identified hazards. A total of 16 hazards (69.6%) were successfully reduced to the Low category with a risk score of 4, and 7 hazards (30.4%) were reduced to the Moderate category with a risk score of 6, as shown in **Table 4**. No hazards in the Substantial or High/Extreme categories were found after the controls were implemented.

Table 4. Summary of Risk Levels After Control Measures

Risk Level	Number of Hazards	Percentage
High/Extreme (17-25)	0	0%
Substantial (10-16)	0	0%
Moderate (5-9)	7	30.4%
Low (1-4)	16	69.6%
Total	23	100%

The seven hazards that remain in the "Moderate" category after mitigation namely, noise from the paper-making machine, electric shock from the oven, being caught in the rollers of the roll machine, being cut by the cutting roll machine, being caught in the ball press, and two electrical hazards in the plant area are inherent to the production process and therefore cannot be completely eliminated, but have been controlled to the greatest extent possible through a combination of engineering controls, administrative controls, and PPE. Overall, all 6 hazards categorized as "Substantial" were successfully reduced five of them to "Moderate" and one to "Low" while 11 of the 17 hazards categorized as "Moderate" were successfully reduced to "Low." These results demonstrate that the HIRADC method, when applied systematically and consistently, is capable of providing effective control recommendations to reduce occupational safety and health (OSH) risk levels in industrial settings, in line with previous research findings that concluded that the comprehensive application of HIRADC can significantly lower hazard risk categories after hierarchy-based controls are implemented [9], [10], [11]. Compared to studies on other subjects, such as the electrical assembly department [5] and the seafood processing industry [9]which still had a number of high-category hazards remaining after controls were implemented the results at PT Trigunapratama Abadi's paper plant show a more comprehensive pattern of risk reductionm because there are no longer any remaining hazards classified as "Substantial" or "High/Extreme" [12], [13],[14],[15] .

4. Conclusion

The application of the HIRADC method at the PT Trigunapratama Abadi Paper Plant successfully identified 23 potential hazards spread across 10 main work activities and one hazard group covering the entire plant area, consisting of physical, mechanical, chemical, ergonomic, and electrical hazards, with physical hazards being the most prevalent. The results of the risk assessment using the likelihood × severity matrix based on the AS/NZS 4360:2004 standard showed that, prior to control measures, 6 hazards (26.1%) were categorized as "Substantial" and 17 hazards (73.9%) were categorized as "Moderate," with no hazards categorized as "Low" or "High/Extreme." After implementing control measures based on the OSH risk control hierarchy including engineering controls, administrative controls, and PPE 16 hazards (69.6%) were successfully reduced to the "Low" category, and 7 hazards (30.4%) remained in the "Moderate" category, with no hazards remaining in the "Substantial" or "High/Extreme" categories. These findings demonstrate that the systematic application of HIRADC effectively reduces OSH risk levels and can serve as the company's official OSH documentation in accordance with Government Regulation No. 50 of 2012 and ISO 45001:2018. The company is advised to immediately implement the control recommendations, particularly those addressing the six hazards categorized as "Substantial," to periodically review the HIRADC documentation, and to routinely measure workplace environmental conditions (noise and air quality), while further research is recommended to expand the scope of HIRADC to all of the company's operational areas and integrate it with other methods such as Job Safety Analysis (JSA) or Failure Mode and Effect Analysis (FMEA).

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6. Abbreviations

K3	Keselamatan dan Kesehatan Kerja
HIRADC	Hazard Identification, Risk Assessment, and Determining Control

HSE	Health, Safety, and Environment
B3	Bahan Berbahaya dan Beracun
APD	Alat Pelindung Diri
SOP	Standard Operating Procedure (Prosedur Kerja Aman)
NAB	Nilai Ambang Batas
MSDs	Musculoskeletal Disorders
HAVS	Hand-Arm Vibration Syndrome
ELCB/RCD	Earth Leakage Circuit Breaker / Residual Current Device

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