Lecture Notes in Networks and Systems 855

Pandian Vasant ·
Mohammad Shamsul Arefin ·
Vladimir Panchenko · J. Joshua Thomas ·
Elias Munapo · Gerhard-Wilhelm Weber ·
Roman Rodriguez-Aguilar *Editors*

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Lecture Notes in Networks and Systems 855

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Editors
Pandian Vasant
Faculty of Electrical and Electronics Engineering, Modeling Evolutionary Algorithms Simulation and Artificial Intelligence
Ton Duc Thang University
Ho Chi Minh City, Vietnam

Vladimir Panchenko
Laboratory of Non-traditional Energy Systems, Department of Theoretical and Applied Mechanics, Federal Scientific Agroengineering Center VIM
Russian University of Transport
Moscow, Russia

Elias Munapo
School of Economics and Decision Sciences
North West University
Mmabatho, South Africa

Roman Rodriguez-Aguilar
Facultad de Ciencias Económicas y Empresariales, School of Economic and Business Sciences
Universidad Panamericana
Mexico City, Mexico

Mohammad Shamsul Arefin
Department of Computer Science
Chittagong University of Engineering and Technology
Chittagong, Bangladesh

J. Joshua Thomas
Department of Computer Science
UOW Malaysia KDU Penang University College
George Town, Malaysia

Gerhard-Wilhelm Weber
Faculty of Engineering Management
Poznań University of Technology
Poznań, Poland

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Preface

The sixth edition of the *International Conference on Intelligent Computing and Optimization (ICO'2023) was held during April 27–28, 2023, at G Hua Hin Resort and Mall, Hua Hin, Thailand*. The objective of the international conference is to bring the global research scholars, experts and scientists in the research areas of intelligent computing and optimization from all over the world to share their knowledge and experiences on the current research achievements in these fields. This conference provides a golden opportunity for global research community to interact and share their novel research results, findings and innovative discoveries among their colleagues and friends. The proceedings of ICO'2023 is published by SPRINGER (in the book series ***Lecture Notes in Networks and Systems***) and indexed by **SCOPUS**.

Almost 70 authors submitted their full papers for the 6th ICO'2023. They represent more than 30 countries, such as Australia, Bangladesh, Bhutan, Botswana, Brazil, Canada, China, Germany, Ghana, Hong Kong, India, Indonesia, Japan, Malaysia, Mauritius, Mexico, Nepal, the Philippines, Russia, Saudi Arabia, South Africa, Sri Lanka, Thailand, Turkey, Ukraine, UK, USA, Vietnam, Zimbabwe and others. This worldwide representation clearly demonstrates the growing interest of the global research community in our conference series. The organizing committee would like to sincerely thank all the authors and the reviewers for their wonderful contribution for this conference. The best and high-quality papers will be selected and reviewed by International Program Committee in order to publish the extended version of the paper in the international indexed journals by SCOPUS and ISI WoS.

This conference could not have been organized without the strong support and help from LNNS SPRINGER NATURE, Easy Chair, IFORS and the Committee of ICO'2023. We would like to sincerely thank *Prof. Roman Rodriguez-Aguiler* (Universidad Panamericana, Mexico) and *Prof. Mohammad Shamsul Arefin* (Daffodil International University, Bangladesh), *Prof. Elias Munapo* (North West University, South Africa) and *Prof. José Antonio Marmolejo Saucedo* (National Autonomous University of Mexico, Mexico) for their great help and support for this conference.

We also appreciate the wonderful guidance and support from *Dr. Sinan Melih Nigdeli* (Istanbul University—Cerrahpaşa, Turkey), *Dr. Marife Rosales* (Polytechnic University of the Philippines, Philippines), *Prof. Rustem Popa* (Dunarea de Jos University, Romania), *Prof. Igor Litvinchev* (Nuevo Leon State University, Mexico), *Dr. Alexander Setiawan* (Petra Christian University, Indonesia), *Dr. Kreangkri Ratchagit* (Maejo University, Thailand), *Dr. Ravindra Boojhawon* (University of Mauritius, Mauritius), *Prof. Mohammed Moshiul Hoque* (CUET, Bangladesh), *Er. Aditya Singh* (Lovely Professional University, India), *Dr. Dmitry Budnikov* (Federal Scientific Agroengineering Center VIM, Russia), *Dr. Deepanjal Shrestha* (Pokhara University, Nepal), *Dr. Nguyen Tan Cam* (University of Information Technology, Vietnam) and *Dr. Thanh Dang Trung* (Thu Dau Mot University, Vietnam). The ICO'2023 committee would like to sincerely thank all the authors, reviewers, **keynote speakers** (*Prof. Roman Rodriguez-Aguiler,*

Prof. Kaushik Deb, Prof. Rolly Intan, Prof. Francis Miranda, Dr. Deepanjal Shrestha, Prof. Sunarin Chanta), **plenary speakers** (*Prof. Celso C. Ribeiro, Prof. José Antonio Marmolejo, Dr. Tien Anh Tran*), session chairs and participants for their outstanding contribution to the success of the 6th ICO'2023 in Hua Hin, Thailand.

Finally, we would like to sincerely thank *Prof. Dr. Janusz Kacprzyk, Dr. Thomas Ditzinger, Dr. Holger Schaepe* and *Ms. Varsha Prabakaran* of **LNNS SPRINGER NATURE** for their great support, motivation and encouragement in making this event successful in the global stage.

April 2023

Dr. Pandian Vasant (Chair)
Prof. Dr. Gerhard-Wilhelm Weber
Prof. Dr. Mohammad Shamsul Arefin
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Dr. Vladimir Panchenko
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Hazard Identification, Risk Assessment and Control (HIRAC) at the Wood Processing Industry

Herry Christian Palit(✉) and Alexander

Industrial Engineering Department, Petra Christian University, Siwalankerto 121-131, Surabaya, Indonesia
herry@petra.ac.id

Abstract. This study discusses the application of Hazard Identification, Risk Assessment, and control (HIRAC) at the wood processing industry which processes raw materials in the form of logs into various sizes of wood. This research was conducted due to the lack of awareness of the management concerning the occupational health and safety of its employees. It can be seen from the high number of accidents, where during 2016–2019 there were 16 cases. The results of the risk assessment using HIRAC showed 6% potential hazard with a low risk level, 29% with a moderate risk level, and 65% with a very high-risk level. Hazard control is focused on potential hazards with a very high-risk level. Hazard control consist of seven type of administrative controls, one type of elimination control, four types of engineering controls, and one type of personal protective equipment control.

Keywords: Hazard identification · Risk assessment · Hazard control · Occupational health and safety

1 Introduction

Occupational health and safety belong to the essential factors influencing towards labor's productivity. In order to be able to work productively, working environment needs to be guaranteed safe and healthy. Hazard Identification and Risk Assessment is a process to define and identify hazard potentials; as well as to assess risk level of possible hazard occurrence by considering both probability and severity level. Every singly industry is required to identify potential hazard and assess its risk level within the process of establishing occupational safety and health guidelines. This risk assessment should be performed by utilizing the guidelines and standards of risk assessment [1]. Based on the proposed risk assessment, precise hazard prevention which eliminates and reduces hazardous potentials can be established.

This research is performed in a wood processing industry in Surabaya cultivating timber as the raw material, into various wood products such as sawn timber, Slice Four Side (S4S), panels, decking, flooring, finger joint, and many others. So far, the industry's

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management has yet to possess consideration towards its labors' safety and health, judging from the absence of reliable occupational hazard prevention and control. This is supported by the data on work-related accidents during 2016–2019, pointing out 16 accidents in which 15 of them are ergonomics-related (as displayed on Table 1). In addition, current working environment also potentially triggers occupational disease for the labors. This can be seen from wood dust scattered on the production floor area, which may trigger breathing and vision problems.

Table 1. Data on work-related accidents

Causing factors	Year			
	2016	2017	2018	2019
Physics	–	–	–	–
Chemics	1	–	–	–
Biology	–	–	–	–
Ergonomics	2	4	3	6
Psychics	–	–	–	–

Source Industrial database

Previous researchers have pointed out that HIRAC implementation in various industries brings various result on the risk hazard percentage level. The implementation of HIRAC in a boiler operation at Indonesian Power Unit, Semarang Ltd. Points out high-risk hazard percentage level in amount of 16.67% [2]. The implementation of HIRAC in the fabrication process at Pertamina Balongan Ltd. Ambarani and Tualeka [3] points out high risk hazard percentage level in amount of 45%, and very high-risk hazard percentage level at 5%. Indrawati et al. [4] points out 22% of high-risk hazard percentage level as a result of HIRAC implementation in a furniture industry. The better the implementation of occupational safety and health guidelines in an industry, the lesser its high and very high-risk hazard level percentage.

This research is aimed to assist corresponding industries in identifying hazard potentials in a production floor, along with their risk level assessment. The higher the risk level, the more effort towards hazard control needs to be done, in order to reduce work-related accidents and work-related disease among the labors. Thus, hazard prevention and control are focused on hazard potentials with high and very high-risk level.

2 Method

Observation and HIRAC implementation are performed by involving both the owner and human resource manager. Their participation begins with identifying hazard potentials; determining probability and severity level for risk assessment; and hazard control on the production floor. There are 142 labors working on the production area, 106 males and 36 females, in which 6 are acting supervisors. They work approximately 40 h a week. During worktime, they are prone to the hazard potentials scattered around their working environment, both work-related accident and work-related disease.

The initial stage for hazard identification is performed to identify process and activities that may trigger work-accident and work-related disease related problems. This is performed by observation utilizing ergonomic checkpoints from International Labor Office [5]. This tool is comprised of separate categories: Material storage and handling, which is intended to observe material storing and mobilization activity on the workspace; Hand tool, intended to observe activities related to the use of tools on the workspace; Machine safety, intended to observe the safety on the use of production machineries on the workspace; Workstation design, intended to observe both safety and convenience of the labors while working on their workspace; Lighting, intended to observe overall lighting and lighting intensity on the workspace; Premises, intended to observe air circulation on the workspace and evacuation system towards potential hazards such as fire and others; Hazardous substance and agents, intended to observe hazardous agents on the workspace; Welfare facilities, intended to observe general facilities; Work organization, intended to observe how the organization make decisions and policies. Hazard identification is afterwards continued by more detailed elaboration, in order to better identify hazard potentials and risks that may occur during activities on the production level area, both work-related accident and work-related disease.

Based on the hazard identification stage, risk assessment is performed by considering the probability of the hazard, and the severity that may occur as an impact. Based on the multiplication process towards probability and severity scores, risk value is obtained. Table 2 presents Risks Assessment Matrix Model to analyze the category of risk level from each of the hazard potential.

Table 2. Risk assessment matrix model

Risk assessment matrix model		Severity				
		Light injury (1)	Moderate injury (2)	Severe injury (3)	Fatality (4)	Disaster (5)
Probability	Very high (5)	Low	Moderate	High	Very high	Very high
	High (4)	Low	Moderate	High	Very high	Very high
	Moderate (3)	Low	Moderate	Moderate	Tinggi	Tinggi
	Low (2)	Low	Low	Moderate	Moderate	Moderate
	Very low (1)	Low	Low	Low	Low	Low

Source Rout and Sikdar [6]

Hazard control mechanism in this research is focused towards hazard potentials with high and very high risk factor. According to the policy established by the Ministry of Labor number 5, 2018 [7], hazard control on the working environment should be performed according to the five hierarchical levels as pointed out by Fig. 1.

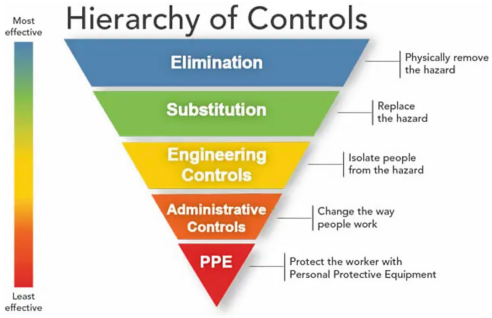

Fig. 1. The hierarchy of workplace environment hazard control

Hazard control in a working environment is performed by conforming priority levels set on the Figure. The first hierarchy, or control through hazard elimination is a first priority. If not possible, then second layer of the control can be utilized.

3 Results and Discussion

Hazard identification is performed by analyzing both of the result of field observation and measurement on the production area. Based on the overall wood processing, 21 activities with hazardous potential are identified. The following are examples list hazard potential during timber receiving, trimming, and maintaining stages.

Mobilizing timber from truck with forklift. This belongs to the receiving and mobilizing stage. Hazard potentials found during this stage include forklift path, which appears to be the same one walked by the labors during their activity. This unorganized route may potentially cause accident, such as a worker may be hit by the forklift.

Operating log trim machinery. This belongs to the trimming process, in which timbers are trimmed by using machineries. These machineries possess hazard potential for the operators, such as amputation, pinching, and direct exposure from the wood dust, noise, hot airflow, and high level of humidity.

Machineries check and repair. This belongs to one of the activities during maintaining stage. Hazard potential in this activity may occur if the machineries suddenly turned on during a repair process.

Risk assessment is performed after hazard identification by utilizing matrix displayed on Table 2. This aims to determine policy priority regarding problems or potential problems. This analysis is divided into two types of risks: work-related accident and work-related disease. Risk assessment is conducted by determining opportunity value and severity rate towards existing hazard potential. Probability assessment and severity risk level involve both owner and human resource manager. The probability of hazard potential related with work-related accident and work-related disease is determined through some values representing the likelihood an accident may occur. This probability is divided into 5 different levels, starting from the lowest level of probability. The description of each level can be seen on Table 3 (for work-related accident) and Table 4 (for work-related disease).

Table 3. Work-related accident probability level description

Level	Description
1	Never happened/heard on the equivalent industries around the world
2	Ever happened/heard on the equivalent industries around the world
3	Ever happened once or more on the late three years, on the equivalent industries around the world
4	Ever happened once or more on the late three years, on the equivalent industries in Indonesia
5	Ever happened once or more on the late three years, on the industry

Source Adaptation from Ardani et al.[8]

Table 4. Work-related disease probability level description

Level	Description
1	Rare exposure and low likelihood of causing disease
2	Low exposure and low likelihood of causing disease
3	Regular/irregular exposure and moderate likelihood of causing disease
4	Frequent exposure and high likelihood of causing disease
5	Constant exposure dan and very high likelihood of causing disease

Source Adaptation from Ambarani and Tualeka[3]

Severity level is assessed in order to find out the impact that may occur if hazard potential turns into realization. This severity level is divided into 5 different levels starting from the lowest severity level. The description of each level can be seen on Table 5 (for work-related accident) and Table 6 (for work-related disease).

The result of probability and severity level is used to determine risk levels, which categorized from the lowest, as pointed out from Table 2. The followings are risk assessments towards hazard potential belonging to very high-risk category.

Mobilizing timbers from a truck, mobilizing timbers on the production floor, and mobilizing timbers to the production storage may inflict accident between forklift and labors. The accident may cause broken bones and death; thus, severity value is given 5. The accident probability is also given 5 considering the fact that such accident happened once in 2019. Based on both severity and probability level, forklift accident is categorized as very high risk.

Operators performing activity around trimming machine may potentially slipped and pinched by a moving wheeled cart. This may result in broken bones or death; thus the severity level is given 5. The probability of accident is also given 5 considering the fact that such accident happened once in 2019. Based on both severity and probability level, wheeled cart accident is categorized as very high risk.

Table 5. Work-related accident severity level description

Level	Description
1	Near miss requires documentation and action
2	Potentially causing injury which require first aid kit
3	Require medical treatment, but does not cause work restriction or worktime lost
4	One or more injuries requiring medical treatment, which cause worktime lost, but does not inflict permanent damage
5	Potentially causing permanent damage or death

Source Adaptation from Ardani et al. [8]

Table 6. Work-related disease severity level description

Level	Description
1	Exposure requires documentation and action
2	Potentially causing disease which require first aid kit
3	Potentially causing disease, but does not cause work restriction or worktime lost
4	Potentially causing temporary disease, but require medical treatment which impacts on worktime lost
5	Potentially causing permanent damage or death

Source Adaptation from Ambarani and Tualeka [3]

The operator of trimming machinery may constantly exposed from wood dust, as he would always be on the same station during his worktime. The possibility of work-related disease is therefore high and given value of 5. Wood dust may cause eyes irritation, occupational asthma, or other chronical obstructive on the ones exposed, therefore severity level is also given 5. Considering such probability and severity level, this exposure is categorized as very high-risk category.

Machinery turned on during maintenance/repairis considered very dangerous and may cause fatality on the victim, such as scratch or dismembered body parts, therefore severity level is given 5. The probability value is also given 5, considering the fact that such accident happened once in 2019. Considering such probability and severity level, this malfunctioning is categorized as very high risk.

The result of assessment towards all activities within production area points out three types of risk categories: high risk in amount of 65%, moderate risk in amount of 29%, and low risk in amount of 6%, as displayed in Fig. 2. This implies that hazard control will be prioritized towards activities containing very high-level risk.

This hazard control aims to reduce risk level and make risks more acceptable. Hazard control is performed towards very high-risk activities. The followings are how hazard control may be implemented towards very high-risk activities.

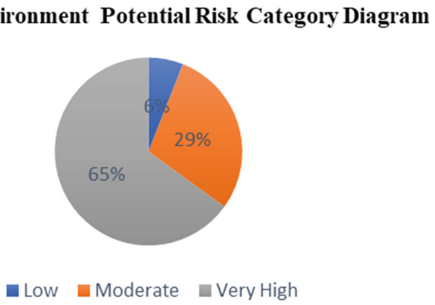

Fig. 2. Working-environment potential risk category diagram

Establishing different path for transportation access and labors access. This control is performed to overcome problems on timber receiving process, temporary storage, and finished products storage. These three processes contain similar activities which is the mobilization of timbers by forklift. This control belongs to technical manipulation category, as the creation of specific path according to the purpose ensure the safety of labors walking on the path. Labors path can be created by applying paint with a-meter wide size in one of the sections of the transportation path. This paint functions to mark the area that can be specifically passed through by labor only. Other transportation devices such as forklift is not allowed to pass through it. Likewise, this control also forbids the labor to walk on the transport path.

Labelling caution sign and designate safe area for the operator. This control aims to overcome problems that may happen during trimming process. Labelling 'caution' sign indicating the danger may prevent labors to walk too close with wheeled cart, therefore reducing pinching accident. This label can be installed on the outer-lower side of the cart. The exact location of the label can be determined by sticking out a sticker in the area. This prevention belongs to administrative category, as it helps labors to avoid area with high level of hazard. Installing wooden barrier on the surrounding of cart track can also support the prevention effort. This belongs to technical manipulation category, as this limits operator movement from slipping backwards.

Installing local exhaust in production machineries and wearing protection devices. The installation of local exhaust belongs to technical manipulation category, as it prevents labors from being exposed to wood dust resulted from the production machineries. Wood dust may inflict eyes irritation, occupational asthma, and chronic diseases for those exposed. Local exhaust can be made in form of a pipe sucking scattered wood dust. The pipe should be pointed to the trimming location where wood dust appears. This prevents wood dust to reach labors' breathing zone (300 mm diameter) [9]. This control can also be achieved by wearing mask and safety google glass. The aforementioned mask is quarter-mask-air-purifying respirator type, which equipped with dust filter made of fiberglass. Safety google glass prevents operator's eyes from the exposure of wood dust, therefore preventing eyes irritation. The application of both mask and safety google glass should be made compulsories for all the workers in the production area. This conforms with the industry's regulation regarding the use of protective devices.

Providing label and marking area with potential hazard (hand caught inside a machine). This is performed especially in wood processing process involving the use of machineries. Providing label or danger sign on the machineries utilized on this stage is aimed to prevent accident caused by labors' hand getting pulled by one of the machines. This control is performed by marking areas forbidden to be touched by the labors' hands. Marking is done by sticking out stickers showing danger sign on the area. This belongs to administrative category, as it helps the labors to avoid areas potentially hazardous towards their body part (in this case, hand getting caught inside a machine).

Locking machine from the power source by using Lock Out/Tag Out (LOTO). LOTO system is a combined system aimed to prevent a machine from turning on during maintenance process. Lock out system locks the power source of a machine to prevent sudden activation, while tag out helps other labors in the vicinity to be aware of an ongoing maintenance process. LOTO system belongs to administrative control category, as labors are required to apply the system first, to ensure that the corresponding machine is isolated from the power source. This can be done by switching off electrical panel of the machine, followed by locking it with a padlock equipped with label explaining ongoing maintenance process. This deactivated and isolated power unit prevents other unaware labors from switching on the machine during maintenance.

For the future, the company is suggested to consider utilizing technology in order to better manage the hazard control. The utilization of safety sensor installed on the machineries and hazardous areas potentially be the hazard control [10, 11]. One of the applications of safety sensor on machineries is proximity sensor. The way this sensor works may vary depending on the transmission of light, ultrasonic, or other kind of waves. In general, proximity sensor transmits wave and calculate its wavelength according to the preset range. If it detects an object, the length of wave received back by the sensor will be different as it is bounced by the object. If any object starts entering hazardous area with conveyor, vacuum, or anything similar, integrated proximity sensor will release a particular warning. Sound or machine that turns off automatically will be made on at the moment proximity sensor detects an object in proximity. Passive Infrared Receiver (PIR) sensor detects any foreign object being too close with the hazardous area will release a loud sound, as a warning towards the object. In addition, the use of wearable technologies to observe workers in real-time and to remove potential hazard is also important to consider. Hazard originated from wood dust and machinery noise can be monitored by wearable technology. The NIOSH Center for Direct Reading and Sensor Technologies (NCDRST) has developed several wearable technologies to improve occupational health and safety [12]. Respirable Dust Sensor Technology can be used to monitor the exposure of wood dust, whether it is still safe or it has trespassed the threshold. Sound level meter apps, utilizing embedded smartphone sensors is a tool to measure noise level in a workplace. This should be supported with noise exposure perimeter to better reduce hearing loss caused by noise in a workplace. With the help of technology, occupational health and safety management is expected to better provide hazard-free environment more effectively in a workplace.

4 Conclusion

The result of this research points out that working environment in the production area potentially harms labors' health and triggers occupational hazards. This can be seen from the number of very high-risk level of activities in amount of 65%, while the 29% is moderate risk level activities, and the remaining 6% as low risk level activities. The activities with very high level of risk becoming the subject priority of hazard control. Proposed hazard control includes seven administrative control category, one elimination control category, four technical manipulation category, and one protective device control category.

References

1. Ramesh, R., Prabu, M., Magibalan, S., Senthilkumar, P.: Hazard identification and risk assessment in automotive industry. Int. J. ChemTech Res. **10**(4), 352–358 (2017)
2. Zeinda, E.M., Hidayat, S.: Risk assessment kecelakaan kerja pada pengoperasian boiler di PT. Indonesia Power Unit Pembangkitan Semarang. Indones. J. Occup. Saf. Health **5**(2), 183–191 (2016)
3. Ambarani, A.Y., Tualeka, A.R.: Hazard identification and risk assessment (HIRA) pada proses fabrikasi plate tanki 42-T-501A PT. Pertamina (PERSERO) RU VI Balongan. Indones. J. Occup. Saf. Health **5**(2), 192–203 (2016)
4. Indrawati, S., Prabaswari, A.D., Fitriyanto, M.A.: Risk control analysis of a furniture production activities using hazard identification and risk assessment method. MATEC Web Conf. **154**, 01102 (2018). https://doi.org/10.1051/matecconf/201815401102
5. International Labour Office: Ergonomic Checkpoints: Practical and Easy-to-Implement Solutions for Improving Safety, Health and Working Conditions. International Labour Office, Switzerland (2010)
6. Rout, B.K., Sikdar, B.K.: Hazard identification, risk assessment, and control measures as an effective tool of occupational health assessment of hazardous process in an iron ore pelletizing industry. Indian J. Occup. Environ. Med. **21**(2), 56–76 (2017). https://doi.org/10.4103/ijoem.IJOEM_19_16
7. Kemenaker: Peraturan Menteri Ketenagakerjaan Republik Indonesia (PERMENAKER) nomor 5 tahun 2018 tentang Keselamatan dan Kesehatan Kerja Lingkungan Kerja. Kementerian Ketenagakerjaan Republik Indonesia, Jakarta (2018)
8. Ardani, H.N., Santoso, H., Rumita, R.: Analisis risiko kesehatan dan keselamatan kerja pada pekerja divisi mill boiler (Studi Kasus di PT Laju Perdana Indah PG Pakis Baru, Pati). Ind. Eng. Online J. **3**(2), 1–6 (2014)
9. Harrianto, R.: Buku Ajar Kesehatan Kerja. Penerbit Buku Kedokteran EGC, Jakarta (2009)
10. Rajendran, S., Giridhar, S., Chaudhari, S., Gupta, P.: Technological advancements in occupational health and safety. Meas. Sens. **15**, 100045 (2021). https://doi.org/10.1016/j.measen.2021.100045
11. Haas, E.J., Cauda, E.: Using core elements of health and safety management systems to support worker well-being during technology integration. Int. J. Environ. Res. Public Health **19**(21), 13849 (2022). https://doi.org/10.3390/ijerph192113849
12. The National Institute for Occupational Safety and Health (NIOSH). https://www.cdc.gov/niosh/programs/cdrst/default.html

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by Herry Christian Palit

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Hazard Identification, Risk Assessment and Control (HIRAC) at The Wood Processing Industry

Herry Christian Palit[1][0000-0002-0349-5059] and Alexander[1]

[1] Industrial Engineering Department, Petra Christian University, Siwalankerto 121-131, Surabaya, Indonesia
herry@petra.ac.id

Abstract. This study discusses the application of Hazard Identification, Risk Assessment, and control (HIRAC) at the wood processing industry which processes raw materials in the form of logs into various sizes of wood. This research was conducted due to the lack of awareness of the management concerning the occupational health and safety of its employees. It can be seen from the high number of accidents, where during 2016 - 2019 there were 16 cases. The results of the risk assessment using HIRAC showed 6% potential hazard with a low risk level, 29% with a moderate risk level, and 65% with a very high-risk level. Hazard control is focused on potential hazards with a very high-risk level. Hazard control consist of seven type of administrative controls, one type of elimination control, four types of engineering controls, and one type of personal protective equipment control.

Keywords: Hazard idenfication, risk assesment, hazard control, occupational health and safety

1 Introduction

Occupational health and safety belong to the essential factors influencing towards labor's productivity. In order to be able to work productively, working environment needs to be guaranteed safe and healthy. Hazard Identification and Risk Assessment is a process to define and identify hazard potentials; as well as to assess risk level of possible hazard occurrence by considering both probability and severity level. Every singly industry is required to identify potential hazard and assess its risk level within the process of establishing occupational safety and health guidelines. This risk assessment should be performed by utilizing the guidelines and standards of risk assessment [1]. Based on the proposed risk assessment, precise hazard prevention which eliminates and reduces hazardous potentials can be established.

This research is performed in a wood processing industry in Surabaya cultivating timber as the raw material, into various wood products such as sawn timber, Slice Four Side (S4S), panels, decking, flooring, finger joint, and many others. So far, the industry's management has yet to possess consideration towards its labors' safety and health, judging from the absence of reliable occupational hazard prevention and control. This is supported by the data on work-related accidents during 2016 – 2019,

pointing out 16 accidents in which 15 of them are ergonomics-related (as displayed on Table 1). In addition, current working environment also potentially triggers occupational disease for the labors. This can be seen from wood dust scattered on the production floor area, which may trigger breathing and vision problems.

Table 1. Data on work-related accidents

Causing Factors	Year			
	2016	2017	2018	2019
Physics	-	-	-	-
Chemics	1	-	-	-
Biology	-	-	-	-
Ergonomics	2	4	3	6
Psychics	-	-	-	-

Source: Industrial Database

Previous researchers have pointed out that HIRAC implementation in various industries brings various result on the risk hazard percentage level. The implementation of HIRAC in a boiler operation at Indonesian Power Unit, Semarang Ltd. points out high-risk hazard percentage level in amount of 16.67% [2]. The implementation of HIRAC in the fabrication process at Pertamina Balongan Ltd. Ambarani and Tualeka points out high risk hazard percentage level in amount of 45%, and very high-risk hazard percentage level level at 5% [3]. Indrawati, Prabaswari, and Fitriyanto points out 22% of high-risk hazard percentage level as a result of HIRAC implementation in a furniture industry [4]. The better the implementation of occupational safety and health guidelines in an industry, the lesser its high and very high-risk hazard level percentage.

This research is aimed to assist corresponding industries in identifying hazard potentials in a production floor, along with their risk level assessment. The higher the risk level, the more effort towards hazard control needs to be done, in order to reduce work-related accidents and work-related disease among the labors. Thus, hazard prevention and control are focused on hazard potentials with high and very high-risk level.

2 Method

Observation and HIRAC implementation are performed by involving both the owner and human resource manager. Their participation begins with identifying hazard potentials; determining probability and severity level for risk assessment; and hazard control on the production floor. There are 142 labors working on the production area, 106 males and 36 females, in which 6 are acting supervisors. They work approximately 40 hours a week. During worktime, they are prone to the hazard potentials scattered

around their working environment, both work-related accident and work-related disease.

The initial stage for hazard identification is performed to identify process and activities that may trigger work-accident and work-related disease related problems. This is performed by observation utilizing ergonomic checkpoints from International Labor Office [5]. This tool is comprised of separate categories: Material storage and handling, which is intended to observe material storing and mobilization activity on the workspace; Hand tool, intended to observe activities related to the use of tools on the workspace; Machine safety, intended to observe the safety on the use of production machineries on the workspace; Workstation design, intended to observe both safety and convenience of the labors while working on their workspace; Lighting, intended to observe overall lighting and lighting intensity on the workspace; Premises, intended to observe air circulation on the workspace and evacuation system towards potential hazards such as fire and others; Hazardous substance and agents, intended to observe hazardous agents on the workspace; Welfare facilities, intended to observe general facilities; Work organization, intended to observe how the organization make decisions and policies. Hazard identification is afterwards continued by more detailed elaboration, in order to better identify hazard potentials and risks that may occur during activities on the production level area, both work-related accident and work-related disease.

Based on the hazard identification stage, risk assessment is performed by considering the probability of the hazard, and the severity that may occur as an impact. Based on the multiplication process towards probability and severity scores, risk value is obtained. Table 2 presents Risks Assessment Matrix Model to analyze the category of risk level from each of the hazard potential.

Table 2. Risk Assessment Matrix Model

Risk Assessment Matrix Model		*SEVERITY*				
		Light Injury (1)	Moderate Injury (2)	Severe Injury (3)	Fatality (4)	Disaster (5)
PROBABILITY	Very High (5)	Low	Moderate	High	Very High	Very High
	High (4)	Low	Moderate	High	Very High	Very High
	Moderate (3)	Low	Moderate	Moderate	Tinggi	Tinggi
	Low (2)	Low	Low	Moderate	Moderate	Moderate
	Very Low (1)	Low	Low	Low	Low	Low

Source: Rout & Sikdar [6]

Hazard control mechanism in this research is focused towards hazard potentials with high and very high risk factor. According to the policy established by the Ministry of Labor number 5, 2018 [7], hazard control on the working environment should be performed according to the five hierarchical levels as pointed out by Figure 1.

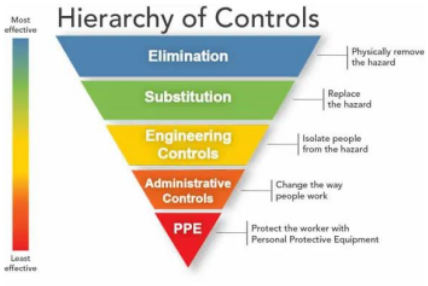

Fig. 1. The hierarchy of workplace environment hazard control

Hazard control in a working environment is performed by conforming priority levels set on the Figure. The first hierarchy, or control through hazard elimination is a first priority. If not possible, then second layer of the control can be utilized.

3 Results and Discussion

Hazard identification is performed by analyzing both of the result of field observation and measurement on the production area. Based on the overall wood processing, 21 activities with hazardous potential are identified. The following are examples list hazard potential during timber receiving, trimming, and maintaining stages.

Mobilizing timber from truck with forklift. This belongs to the receiving and mobilizing stage. Hazard potentials found during this stage include forklift path, which appears to be the same one walked by the labors during their activity. This unorganized route may potentially cause accident, such as a worker may be hit by the forklift.

Operating log trim machinery. This belongs to the trimming process, in which timbers are trimmed by using machineries. These machineries possess hazard potential for the operators, such as amputation, pinching, and direct exposure from the wood dust, noise, hot airflow, and high level of humidity.

Machineries check and repair. This belongs to one of the activities during maintaining stage. Hazard potential in this activity may occur if the machineries suddenly turned on during a repair process.

Risk assessment is performed after hazard identification by utilizing matrix displayed on Table 2. This aims to determine policy priority regarding problems or potential problems. This analysis is divided into two types of risks: work-related accident and work-related disease. Risk assessment is conducted by determining opportunity value and severity rate towards existing hazard potential. Probability assessment and severity risk level involve both owner and human resource manager. The probability of hazard potential related with work-related accident and work-related disease is determined through some values representing the likelihood an accident

may occur. This probability is divided into 5 different levels, starting from the lowest level of probability. The description of each level can be seen on Table 3 (for work-related accident) and Table 4 (for work-related disease).

Table 3. Work-related accident probability level description

Level	Description
1	Never happened / heard on the equivalent industries around the world
2	Ever happened / heard on the equivalent industries around the world
3	Ever happened once or more on the late three years, on the equivalent industries around the world
4	Ever happened once or more on the late three years, on the equivalent industries in Indonesia
5	Ever happened once or more on the late three years, on the industry

Source: Adaptation from Ardani, et al [8]

Table 4. Work-related disease probability level description

Level	Description
1	Rare exposure and low likelihood of causing disease
2	Low exposure and low likelihood of causing disease
3	Regular / irregular exposure and moderate likelihood of causing disease
4	Frequent exposure and high likelihood of causing disease
5	Constant exposure dan and very high likelihood of causing disease

Source: Adaptation from Ambarani & Tualeka [3]

Severity level is assessed in order to find out the impact that may occur if hazard potential turns into realization. This severity level is divided into 5 different levels starting from the lowest severity level. The description of each level can be seen on Table 5 (for work-related accident) and Table 6 (for work-related disease).

The result of probability and severity level is used to determine risk levels, which categorized from the lowest, as pointed out from Table 2. The followings are risk assessments towards hazard potential belonging to very high-risk category.

Mobilizing timbers from a truck, mobilizing timbers on the production floor, and mobilizing timbers to the production storage may inflict accident between forklift and labors. The accident may cause broken bones and death; thus, severity value is given 5. The accident probability is also given 5 considering the fact that such accident happened once in 2019. Based on both severity and probability level, forklift accident is categorized as very high risk.

Operators performing activity around trimming machine may potentially slipped and pinched by a moving wheeled cart. This may result in broken bones or death; thus the severity level is given 5. The probability of accident is also given 5 considering the fact that such accident happened once in 2019. Based on both severity and probability level, wheeled cart accident is categorized as very high risk.

Table 5. Work-related accident severity level description

Level	Description
1	Near miss requires documentation and action
2	Potentially causing injury which require first aid kit
3	Require medical treatment, but does not cause work restriction or worktime lost
4	One or more injuries requiring medical treatment, which cause worktime lost, but does not inflict permanent damage
5	Potentially causing permanent damage or death

Source: Adaptation from Ardani, et al [8]

Table 6. Work-related disease severity level description

Level	Description
1	Exposure requires documentation and action
2	Potentially causing disease which require first aid kit
3	Potentially causing disease, but does not cause work restriction or worktime lost
4	Potentially causing temporary disease, but require medical treatment which impacts on worktime lost
5	Potentially causing permanent damage or death

Source: Adaptation from Ambarani & Tualeka [3]

The operator of trimming machinery may constantly exposed from wood dust, as he would always be on the same station during his worktime. The possibility of work-related disease is therefore high and given value of 5. Wood dust may cause eyes irritation, occupational asthma, or other chronical obstructive on the ones exposed, therefore severity level is also given 5. Considering such probability and severity level, this exposure is categorized as very high-risk category.

Machinery turned on during maintenance/repairis considered very dangerous and may cause fatality on the victim, such as scratch or dismembered body parts, therefore severity level is given 5. The probability value is also given 5, considering the fact that such accident happened once in 2019. Considering such probability and severity level, this malfunctioning is categorized as very high risk.

The result of assessment towards all activities within production area points out three types of risk categories: high risk in amount of 65%, moderate risk in amount of 29%, and low risk in amount of 6%, as displayed in Figure 2. This implies that hazard control will be prioritized towards activities containing very high-level risk.

This hazard control aims to reduce risk level and make risks more acceptable. Hazard control is performed towards very high-risk activities. The followings are how hazard control may be implemented towards very high-risk activities.

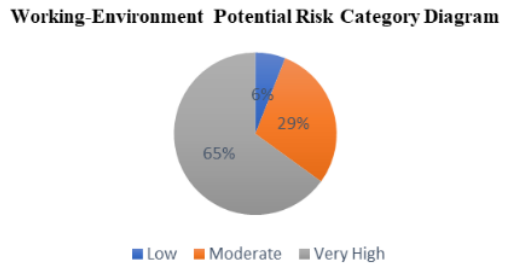

Fig. 2. Working-environment potential risk category diagram

Establishing different path for transportation access and labors access. This control is performed to overcome problems on timber receiving process, temporary storage, and finished products storage. These three processes contain similar activities which is the mobilization of timbers by forklift. This control belongs to technical manipulation category, as the creation of specific path according to the purpose ensure the safety of labors walking on the path. Labors path can be created by applying paint with a-meter wide size in one of the sections of the transportation path. This paint functions to mark the area that can be specifically passed through by labor only. Other transportation devices such as forklift is not allowed to pass through it. Likewise, this control also forbids the labor to walk on the transport path.

Labelling caution sign and designate safe area for the operator. This control aims to overcome problems that may happen during trimming process. Labelling 'caution' sign indicating the danger may prevent labors to walk too close with wheeled cart, therefore reducing pinching accident. This label can be installed on the outer-lower side of the cart. The exact location of the label can be determined by sticking out a sticker in the area. This prevention belongs to administrative category, as it helps labors to avoid area with high level of hazard. Installing wooden barrier on the surrounding of cart track can also support the prevention effort. This belongs to technical manipulation category, as this limits operator movement from slipping backwards.

Installing local exhaust in production machineries and wearing protection devices. The installation of local exhaust belongs to technical manipulation category, as it prevents labors from being exposed to wood dust resulted from the production machineries. Wood dust may inflict eyes irritation, occupational asthma, and chronic diseases for those exposed. Local exhaust can be made in form of a pipe sucking scattered wood dust. The pipe should be pointed to the trimming location where wood dust appears. This prevents wood dust to reach labors' breathing zone (300 mm diameter) [9]. This control can also be achieved by wearing mask and safety google glass. The aforementioned mask is quarter-mask-air-purifying respirator type, which equipped with dust filter made of fiberglass. Safety google glass prevents operator's eyes from the exposure of wood dust, therefore preventing eyes irritation. The application of both mask and safety google glass should be made compulsories for all the

workers in the production area. This conforms with the industry's regulation regarding the use of protective devices.

Providing label and marking area with potential hazard (hand caught inside a machine). This is performed especially in wood processing process involving the use of machineries. Providing label or danger sign on the machineries utilized on this stage is aimed to prevent accident caused by labors' hand getting pulled by one of the machines. This control is performed by marking areas forbidden to be touched by the labors' hands. Marking is done by sticking out stickers showing danger sign on the area. This belongs to administrative category, as it helps the labors to avoid areas potentially hazardous towards their body part (in this case, hand getting caught inside a machine).

Locking machine from the power source by using Lock Out / Tag Out (LOTO). LOTO system is a combined system aimed to prevent a machine from turning on during maintenance process. Lock out system locks the power source of a machine to prevent sudden activation, while tag out helps other labors in the vicinity to be aware of an ongoing maintenance process. LOTO system belongs to administrative control category, as labors are required to apply the system first, to ensure that the corresponding machine is isolated from the power source. This can be done by switching off electrical panel of the machine, followed by locking it with a padlock equipped with label explaining ongoing maintenance process. This deactivated and isolated power unit prevents other unaware labors from switching on the machine during maintenance.

For the future, the company is suggested to consider utilizing technology in order to better manage the hazard control. The utilization of safety sensor installed on the machineries and hazardous areas potentially be the hazard control [10], [11]. One of the applications of safety sensor on machineries is proximity sensor. The way this sensor works may vary depending on the transmission of light, ultrasonic, or other kind of waves. In general, proximity sensor transmits wave and calculate its wavelength according to the preset range. If it detects an object, the length of wave received back by the sensor will be different as it is bounced by the object. If any object starts entering hazardous area with conveyor, vacuum, or anything similar, integrated proximity sensor will release a particular warning. Sound or machine that turns off automatically will be made on at the moment proximity sensor detects an object in proximity. Passive Infrared Receiver (PIR) sensor detects any foreign object being too close with the hazardous area will release a loud sound, as a warning towards the object. In addition, the use of wearable technologies to observe workers in real-time and to remove potential hazard is also important to consider. Hazard originated from wood dust and machinery noise can be monitored by wearable technology. The NIOSH Center for Direct Reading and Sensor Technologies (NCDRST) has developed several wearable technologies to improve occupational health and safety [12]. Respirable Dust Sensor Technology can be used to monitor the exposure of wood dust, whether it is still safe or it has trespassed the threshold. Sound level meter apps, utilizing embedded smartphone sensors is a tool to measure noise level in a workplace. This should be supported with noise exposure perimeter to better reduce hearing loss caused by noise in a workplace. With the help of technology, occupational health and safety management is expected to better provide hazard-free environment more effectively in a workplace.

3 Conclusion

The result of this research points out that working environment in the production area potentially harms labors' health and triggers occupational hazards. This can be seen from the number of very high-risk level of activities in amount of 65%, while the 29% is moderate risk level activities, and the remaining 6% as low risk level activities. The activities with very high level of risk becoming the subject priority of hazard control. Proposed hazard control includes seven administrative control category, one elimination control category, four technical manipulation category, and one protective device control category.

References

1. Ramesh, R., Prabu, M., Magibalan, S., and Senthilkumar, P.: Hazard Identification and Risk Assessment in Automotive Industry. International Journal of ChemTech Research. 10(4), 352--358 (2017)
2. Zeinda, E.M., Hidayat, S.: Risk assessment kecelakaan kerja pada pengoperasian boiler di PT. Indonesia Power Unit Pembangkitan Semarang. The Indonesian Journal of Occupational Safety and Health. 5(2), 183--191 (2016)
3. Ambarani, A.Y., Tualeka, A.R.: Hazard identification and risk assessment (HIRA) pada proses fabrikasi plate tanki 42-T-501A PT. Pertamina (PERSERO) RU VI Balongan. The Indonesian Journal of Occupational Safety and Health. 5(2), 192--203 (2016)
4. Indrawati, S., Prabaswari, A.D., Fitriyanto, M.A.: Risk control analysis of a furniture production activities using hazard identification and risk assessment method. MATEC Web of Conferences 154, 01102 (2018) https://doi.org/10.1051/matecconf/201815401102 (2018)
5. International Labour Office.: Ergonomic checkpoints: Practical and easy-to-implement solutions for improving safety, health and working conditions. International Labour Office, Switzerland (2010)
6. Rout, B.K., Sikdar, B.K.: Hazard identification, risk assessment, and control measures as an effective tool of occupational health assessment of hazardous process in an iron ore pelletizing industry. Indian Journal of Occupational & Environmental Medicine. 21(2), 56--76 (2017) https://doi.org/10.4103/ijoem.IJOEM_19_16
7. Kemenaker.: Peraturan Menteri Ketenagakerjaan Republik Indonesia (PERMENAKER) nomor 5 tahun 2018 tentang Keselamatan dan Kesehatan Kerja Lingkungan Kerja. Kementerian Ketenagakerjaan Republik Indonesia, Jakarta (2018)
8. Ardani, H.N, Santoso, H., Rumita, R.: Analisis risiko kesehatan dan keselamatan kerja pada pekerja divisi mill boiler (Studi Kasus di PT Laju Perdana Indah PG Pakis Baru, Pati). Industrial Engineering Online Journal. 3(2), 1--6 (2014)
9. Harrianto, R.: Buku Ajar Kesehatan Kerja. Penerbit Buku Kedokteran EGC, Jakarta (2009)
10. Rajendran, S., Giridhar, S., Chaudhari, S. & Gupta, P.: Technological advancements in occupational health and safety. Meas. Sens (2021) https://doi.org/10.1016/j.measen.2021.100045
11. Haas EJ, Cauda E.: Using Core Elements of Health and Safety Management Systems to Support Worker Well-Being during Technology Integration. International Journal of Environmental Research and Public Health. 19(21), 13849 (2022) https://doi.org/10.3390/ijerph192113849
12. The National Institute for Occupational Safety and Health (NIOSH), https://www.cdc.gov/niosh/programs/cdrst/default.html

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