

Analysis of TEF Operational Risk Management for Trains and Underground Stations of MRT Jakarta

Unggul Wahyu Aji^{1*}, Sugeng Santoso²
Mercu Buana University

Corresponding Author: Unggul Wahyu Aji unggulanji42@gmail.com

ARTICLE INFO

Keywords: Risk Management, TEF, HIRADC, ISO31000, RCA

Received : 14, August

Revised : 26, August

Accepted: 27, September

©2024 Aji, Santoso : This is an open-access article distributed under the terms of the [Creative Commons Atribusi 4.0 Internasional](https://creativecommons.org/licenses/by/4.0/).



ABSTRACT

This research analyzes risk management related to "TEF Operations on MRT Jakarta's Underground Trains and Stations" using HIRADC, referencing AS/NZ4360 standards and its derivatives in ISO 31000, as well as root cause analysis such as fishbone and 5 why analysis. The objectives are as follows, identify potential risks due to changes in TEF operations, provide recommendations to mitigate these risks, and establish suitable and safe TEF operational methods for underground trains and stations. The study identified 33 potential risks from changes in TEF operations on MRT Jakarta's underground system. Additionally, 17 managerial actions were recommended to minimize these risks. Manual TEF operations are deemed more suitable since the automated TEF operation poses a high-risk category that requires control.

INTRODUCTION

PT MRT Jakarta is a public transportation service provider with electric trains, connecting 13 stations: 7 elevated and 6 underground. For the underground stations, the trains pass through tunnels that require a special ventilation system, known as the Tunnel Ventilation System (TVS). TVS is equipped with a Trackway Exhaust Fan (TEF) that controls the air conditions in the tunnels, operated manually from the Operations Command Centre (OCC) or through control panels at each station. The TEF operates nearly 18 hours a day, necessitating extra maintenance, high operational costs, and several issues related to air efficiency.

The operation of TEF requires routine maintenance such as unit checks, lubrication, blade cleaning, and replacement of spare parts. Additionally, the operational costs of the TEF are very high, approximately Rp12,000,000 per day for all underground stations. The operation of TEF also causes issues such as the extraction of cold air from the station's cooling system, which increases the operational load and causes condensation, reducing safety points from the Department of Transportation. There is also an indication that TEF works inefficiently during non-peak hours.

To address these issues, MRT Jakarta has implemented new scenarios: operating the TEF based on odd-even dates and tunnel temperature. In the odd-even date scenario, the TEF operates alternately every day to reduce operational load. In the tunnel temperature scenario, the TEF will operate automatically if the temperature reaches the upper limit and stops at the lower limit, making it more efficient compared to the previous manual operation.

These changes have a positive impact on efficiency but introduce new risks such as the reliability of temperature sensors and the readiness of the team for manual operation if the automatic system fails. Therefore, an in-depth study is needed to identify other potential risks and how to address them. This study will also help determine whether the new TEF operational methods are truly safe and effective.

This research aims to identify risks arising from changes in TEF operations, determine mitigation actions, and develop safe and efficient operational methods for the underground stations of MRT Jakarta. The results of this study are expected to provide better TEF operational solutions and serve as a reference for further research in the field of underground train operations.

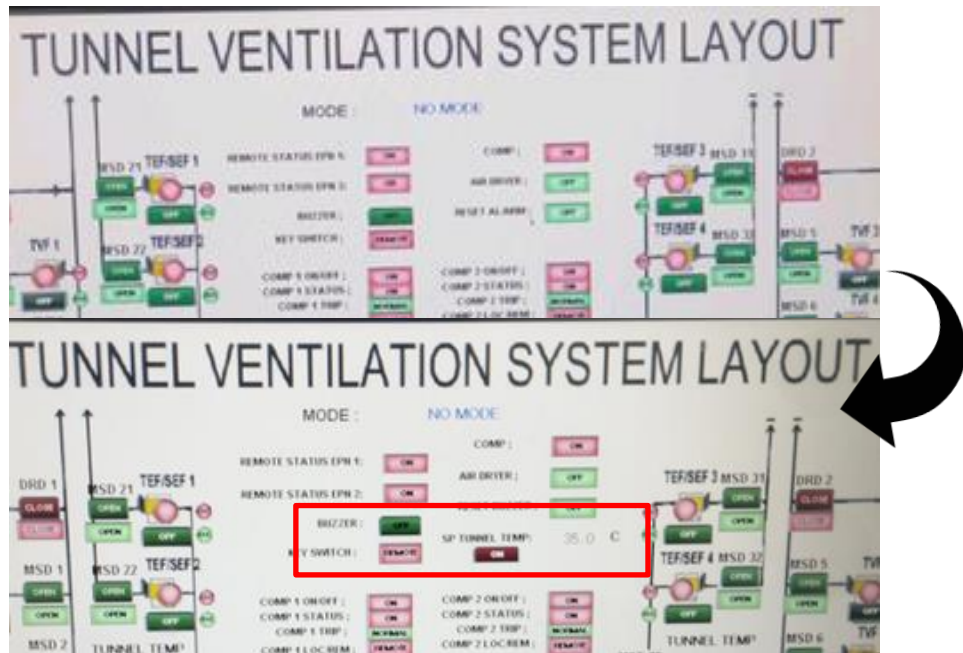


Figure 1. Trackway Exhaust Fan control

THEORETICAL REVIEW

Operational business process of TEF MRT Jakarta

PT MRT Jakarta ensures the safety of tunnels by controlling the temperature through the Environmental Control System (ECS), which includes the Trackway Exhaust Fan (TEF) subsystem. The TEF functions to expel hot air generated from train operations and environmental conditions. (Wen et al., 2020). The operation of the TEF can be automated through the central control system or manually from the station panel. This TEF system is integrated with supporting components such as dampers, electrical panels, and temperature sensors. The TEF can also function as an air circulator and smoke extractor in the event of a fire, ensuring that air conditions in the tunnel remain safe. (Izadi et al., 2022).

Maintenance of the TEF is carried out every three months to maintain its performance, including mechanical checks such as the impeller and shaft, as well as electrical inspections on the electromotor. Additionally, an examination of the signal interconnection between the TEF and other supporting components is conducted. (Long et al., 2021) This overall maintenance is essential to ensure that the TEF operates optimally, supporting the operation of trains and underground stations of MRT Jakarta by maintaining temperature stability and air circulation within the tunnels.

HIRADC (Hazard Risk Assessment & Determining Control)

The HIRADC method (Hazard Identification, Risk Assessment, and Determining Control) is a process to identify, assess, and control hazards in both routine and non-routine work activities or processes. (S. Santoso, Anjela, et al., 2021). Based on OHSAS 18001, which is an international standard for Occupational Health and Safety Management Systems (SMK3), organizations must be able to control all occupational health and safety risks related to

organizational structure, work mechanisms, planning, and maintenance of OHS policies. The HIRADC process includes hazard identification, risk assessment based on probability and severity levels, and determining effective control measures (Su, Santoso et al., 2020). The combination of these risk assessment parameters allows organizations to prevent negative risks or minimize their impact through appropriate strategies.

The stages of HIRADC involve hazard identification, risk assessment, evaluation of existing controls, and prioritization of risks (Mardiansyah et al., 2019). The process involves development of management strategies, implementation of controls, and continuous monitoring and updating. This process aims to reduce workplace risks and enhance safety by developing and implementing additional controls, changing procedures, or providing training to employees. Documentation of the entire HIRADC process is crucial for safety audits and ensuring compliance with safety standards. (Cholil & Santoso, 2020). With these steps, organizations can create a safer and healthier work environment and meet international standards requirements such as OHSAS 18001 and other risk management standards. (S. Santoso & Mayrifka, 2019).

Managerial Implication

The managerial implications are the consequences or impacts that arise from management decisions and actions within an organization (Seldon Magfiroh dan Rudi Wibowo et al., 2019). In this research, the results can be utilized by management in making decisions regarding operational TEF planning, decision-making, resource management, and further development.

Root Cause Analysis

One of the tools of root cause analysis is fishbone diagram. fishbone diagram, or cause-and-effect diagram, helps identify various factors that influence the quality and outcomes of a problem being studied (Rahayu & Santoso, 2021). This diagram, resembling a fishbone, highlights six main factors: human (the people involved and their influences), method (the way or process performed), machine (the equipment used), material (the raw materials used), measurement (the data generated), and environment (the surrounding conditions of the process or problem). (S. Santoso, Aulia, et al., 2021). Each of these factors can significantly contribute to the analyzed problem and help identify root causes for improvement. (S. Santoso et al., 2024)

The other, 5 why method. The 5 Whys method is an analysis technique used to identify the root cause of a problem by repeatedly asking the question "why" until the underlying cause is revealed. (S. Santoso & Mayrifka, 2019).

Framework

The framework of this research consists of two main stages: the first stage involves the operational risk assessment of TEF at MRT Jakarta using HIRADC, and the second stage involves root cause analysis using a Fishbone Diagram & 5 why to determine appropriate TEF operational steps for the normal operation of MRT Jakarta.

METHODOLOGY

This research uses a qualitative method that focuses on interpreting data obtained through analysis. It is conducted as a case study on specific phenomena, times, and activities to gain deep knowledge and detailed explanations about a phenomenon, resulting in a detailed description.

This qualitative research consists of three interacting aspects: place, actors, and activities. The place aspect focuses on the location at the Underground stations of MRT Jakarta. The actors include personnel responsible for related activities, and the activities aspect involves supervision, maintenance, procurement, and delivery. There are 3 key informants in this study. Furthermore, the sampling method used in this research employs purposive sampling technique where the samples are individuals believed to have the most knowledge about the topic being studied.

RESULTS

Risk Identification

The risk management process using the HIRADC method, according to the AS/NZ 4360 (2004) standard also adopted by SNI ISO 31000, involves risk assessment based on two variables: likelihood and consequences. The goal of risk identification is to anticipate potential risks that can affect the operational TEF, by estimating the likelihood, causes, and impacts of these risks. Data for risk identification is gathered through field observations, in-depth interviews, questionnaires, and focused group discussions (FGDs). The validated results of this risk identification are presented in tabular form to facilitate further analysis. In this study, based on in-depth interviews and verification, three root causes were identified: unreliable sensor equipment, ineffective communication flow, and competency of personnel.

Table 1. Risk Identification Result

Activity	Target	Code	Risk Event	Code	Risk Cause
Monitoring	A good monitoring report from the station team and the OCC.	R1	Monitoring activities are not conducted regularly.	A1	The station staff have other duties.
				A2	There are unpredicted operational disruptions.
				A3	The staff are negligent in conducting monitoring.
Operational	Prevention of errors in tunnel temperature sensors.	R2	There is a temperature reading error by the tunnel temperature sensor.	A4	Poor connectivity of temperature devices
				A5	Incorrect maintenance of tunnel temperature

Activity	Target	Code	Risk Event	Code	Risk Cause		
					devices		
	Taking correct initial action when a disruption occurs in the TEF.	R3	The TEF cannot be operated automatically	A6	Power disruption		
				A7	Disruption in the TEF unit (mechanical/electrical)		
				A8	The TEF support system (damper) failed to be operated automatically		
				A9	The operator is unable to operate the TEF automatic control panel		
				A10	Access to the TEF manual panel is obstructed		
		R4	The TEF cannot be operated manually	A11	Disruption in the TEF unit (mechanical/electrical)		
				A12	The TEF support system (damper) failed to be operated manually		
				A13	The operator is unable to operate the TEF manual control panel		
				R5	An alarm is triggered on the train due to high tunnel temperature	A14	Environmental conditions cause an increase in tunnel temperature
						A15	The TEF system is not operational
Maintenance & corrective	Operational feasibility report for TEF	R6	The operational feasibility report for TEF is not available	A16	The checklist activities were not carried out		
				A17	Wrong checklist method		
				A18	Error in instrument tools reading during checklist activity		
				A19	The measuring instrument is not available / damaged		

Activity	Target	Code	Risk Event	Code	Risk Cause	
		R7	Error in performing repairs	A20	The personnel did not follow the SOP (Standard Operating Procedure)	
				A21	Obsolete SOP	
				A22	The maintenance personnel are incompetent	
		Integration of operational feasibility information	R8	Miscommunication among personnel	A23	Lack of communication between maintenance personnel and operational staff
					A24	Information not conveyed during shift changes
Evacuation	Passenger and personnel safety during tunnel evacuation	R9	Chaos occurred during the evacuation of passengers from the train	A25	Server/database communication media disruption	
				A26	The train passengers panicked	
				A27	Inadequate evacuation support facilities	
				A28	Slow evacuation process	
		A29	Passengers not following instructions from personnel			
		A30	The personnel have a limited understanding of the evacuation procedures			
		Readiness of evacuation support facilities	R10	Inadequate evacuation facilities	A31	Insufficient number of evacuation facilities
					A32	The evacuation facilities are damaged
A33	Use of inadequate evacuation facilities					

Risk Analysis

Risk analysis aims to determine the consequences and likelihood of each risk occurring before decision-making, in accordance with the AS/NZS 4360:1999 and ISO 31000 standards. Risks are assessed based on consequences and likelihood, with four levels of risk: low, moderate, high, and extreme in the

repair-operational process. There are differences in the number of risks due to variations in supervisory areas and differing perceptions.

This analysis process involves evaluating the likelihood and impact levels, with the risk scale determination validated through discussions with key informants. This approach ensures effective risk identification and management before implementing control measures. The risk management process follows the HIRADC method, in accordance with AS/NZ standards. The risk assessment scale in the context of TEF operations at MRT Jakarta is based on historical data related to overall activity incidents.

Table 2 Likelihood & Consequences

Scale	Likelihood (L) Description	Consequences (C) Description
1	Rare to happen Possibility of occurring ≤ 1 time in 1 year	Train delay ≤ 1 minute
2	Unlikely to happen Possibility of occurring 2-4 times per year	Train delay 1-2 minute
3	Possible to happen Possibility of occurring 5-10 times per year	Train delay 2-3 minute
4	Likely to happen Possibility of occurring 10-20 times per year	Train delay 4-5 minute
5	Almost certain to happen Possibility of occurring > 20 times per year	Train delay more than 5 minute

Furthermore, risk assessment using the AS/NZ 4360 and ISO 31000 standards categorizes risk scores into categories based on the assessment scale. Risks are classified as low if the score is 1-3, moderate if 4-9, high if 10-16, and extreme if 20-25.

Based on the results of in-depth interviews conducted in this study, there are 10 identified risk causes based on the actual conditions at the research site. These risk causes were derived from historical data and the experiences of key informants due to internal and external factors of the company, both rare and recurring occurrences.

Table 3. Risk Categories

Activities	Code	Risk Cause	Likelihood (L) (1-5)	Consequences (C) (1 - 5)	Risk Rating (L x C)	Categories (L,M,H,E)
Monitoring	A1	The station staff have other duties.	5	1	5	M
	A2	There are unpredicted	5	2	10	H

Activities	Code	Risk Cause	Likelihood (L) (1-5)	Consequences (C) (1 - 5)	Risk Rating (L x C)	Categories (L,M,H,E)
Operational		operational disruptions.				
	A3	The staff are negligent in conducting monitoring.	4	1	4	M
	A4	Poor connectivity of temperature devices	2	1	2	L
	A5	Incorrect maintenance of tunnel temperature devices	2	1	2	L
	A6	Power disruption	2	5	10	H
	A7	Disruption in the TEF unit (mechanical/electrical)	3	1	3	L
	A8	The TEF support system (damper) failed to be operated automatically	3	1	3	L
	A9	The operator is unable to operate the TEF automatic control panel	3	1	3	L
	A10	Access to the TEF manual panel is obstructed	1	1	1	L
	A11	Disruption in the TEF unit (mechanical/electrical)	3	1	3	L

Activities	Code	Risk Cause	Likelihood (L) (1-5)	Consequences (C) (1 - 5)	Risk Rating (L x C)	Categories (L,M,H,E)
	A12	The TEF support system (damper) failed to be operated manually	3	1	3	L
	A13	The operator is unable to operate the TEF manual control panel	2	2	4	M
	A14	Environmental conditions cause an increase in tunnel temperature	1	1	1	L
	A15	The TEF system is not operational	2	2	4	L
Maintenance & corrective	A16	The checklist activities were not carried out	5	1	5	M
	A17	Wrong checklist method	5	1	5	M
	A18	Error in instrument tools reading during checklist activity	5	1	5	M
	A19	The measuring instrument is not available / damaged	5	1	5	M
	A20	The personnel did not follow the SOP (Standard Operating	5	2	10	H

Activities	Code	Risk Cause	Likelihood (L) (1-5)	Consequences (C) (1 - 5)	Risk Rating (L x C)	Categories (L,M,H,E)
		Procedure)				
	A21	Obsolete SOP	5	1	5	M
	A22	The maintenance personnel are incompetent	4	1	4	M
	A23	Lack of communication between maintenance personnel and operational staff	2	2	4	M
	A24	Information not conveyed during shift changes	3	2	6	M
	A25	Server/datab ase communication media disruption	2	1	2	L
Evacuatio n	A26	The train passengers panicked	1	5	5	M
	A27	Inadequate evacuation support facilities	1	5	5	M
	A28	Slow evacuation process	1	5	5	M
	A29	Passengers not following instructions from personnel	1	5	5	M
	A30	The personnel have a limited understanding of the	1	5	5	M

Activities	Code	Risk Cause	Likelihood (L) (1-5)	Consequences (C) (1 - 5)	Risk Rating (L x C)	Categories (L,M,H,E)
		evacuation procedures				
	A31	Insufficient number of evacuation facilities	1	5	5	M
	A32	The evacuation facilities are damaged	1	5	5	M
	A33	Use of inadequate evacuation facilities	1	5	5	M

This risk assessment is conducted after discussions and interviews with key informants to produce a validated risk matrix. The risk analysis table describes the three highest risks categorized as High Risk: (A2) operational disruptions beyond predictions, (A6) power supply disruptions, and (A20) non-compliance of personnel with SOP's.

Risk Evaluation

In this study, risk evaluation was conducted on risks categorized as High & Extreme according to the AS/NZ 4360 and ISO 31000 standards. Risks categorized as High require special attention from management, while risks categorized as Extreme necessitate immediate actions to mitigate their impact or prevent their occurrence. The evaluation process involved discussions and interviews with expert sources to determine necessary steps to reduce risks to the Moderate and Low categories. Implementing these standards allows for managing these risks by improving procedures and appointing competent personnel. Based on interview findings, the target of risk evaluation is to downgrade High and Extreme risks to Moderate and Low. The three risks identified in the High category, namely A2, A6, and A20, are expected to be managed and controlled through recommended control programs, as discussed with key informants.

Table 4. Risk Evaluation

Code	Risk Cause	Likelihood (L)	Consequences (C)	Risk Rating (L x C)	Categories (L,M,H,E)	Recommendation of Controlling Program
A2	There are unpredictable	5	1	5	M	Periodically and continuousl

	operational disruptions					y mitigate all operational risks, especially those related to TEF.
						Conduct regular external audits to seek external perspectives on company risks.
A6	Power disruption	2	4	8	M	Add backup operational power supply lines
A20	The personnel did not follow the SOP (Standard Operating Procedure)	4	1	4	L	Provide education, training, and certification to personnel. Conduct assessments of the SOPs being used.

Root Cause Analysis

The root cause analysis in this study aims to identify the causes of emerging risks, with the goal of reducing or even eliminating their risk levels. The use of tools such as the fishbone diagram & 5 why helps identify the root causes from various factors like man, material, measurement, machine, method, & environment. The root cause analysis process involves discussions with key informants 1, 2 & 3, focusing on risks categorized as Extreme and High. According to the AS/NZ 4360 and ISO 31000 standards, risks categorized as High require special attention from management, while risks categorized as Extreme necessitate immediate actions to minimize their impact or prevent their occurrence.

Based on observations and discussions with key informants, the risk of A2, which involves unpredictable operational disruptions and is categorized as high risk, was analyzed using a fishbone diagram. The causes of risk A2 include the Man factor, where staff are unprepared and lack understanding of technical

equipment and handling disruptions. The Measurement factor involves audit results that have not been uniformly communicated to all staff levels. The Environment factor relates to the design of the building, which is underground, posing higher operational risks compared to conventional buildings. The 5 Why's analysis revealed that the root cause of risk A2 is the non-structural/non-organic team, which has a low risk in the rotation process. The proposed solution is to assess staff capabilities in analyzing potential disruptions as a criterion for rotation and to increase the training interval related to the analysis of potential disruptions for staff

Based on observations and discussions with key informants, the risk of A6, which involves disruptions to electrical power and is categorized as high risk, was analyzed using a fishbone diagram. The causes of risk A6 include the Man factor, which relates to the uneven distribution of standby personnel. The Materials factor involves the electrical supply being provided by only one supplier. The Machine factor pertains to the current generator's inability to back up the entire operational load during a blackout. The 5 Why's analysis revealed that the root cause of risk A6 is due to internal business process issues of the power supplier. The proposed solution is to find another supplier capable of providing electrical power or to build a power plant managed internally by the company.

Based on observations and discussions with key informants, the risk of A20, which involves personnel not following SOPs and is categorized as high risk, was analyzed using a fishbone diagram. The causes of risk A20 include the Man factor, which is the lack of supervision during repair/maintenance processes. The Materials factor involves maintenance/repair SOPs that are not adequate. The Machine factor relates to the reliability of equipment not being ensured (not certified). The 5 Why's analysis revealed that the root cause of risk A20 is the high cost of training/certification. The proposed solution is to increase the budget for training/certification and/or use CCTV technology as a medium to supervise work processes.

Based on discussions with key informants using HIRADC analysis, fishbone diagrams, and the 5 Why's analysis, the managerial implications can be summarized as follows:

Table 5. Managerial implications

No	Program recommendation	Target
1	Regularly and continuously mitigate all operational and non-operational risks, especially those related to TEF	Mapping out operational risks and implementing appropriate actions to minimize and expedite their handling.
2	Conduct regular external audits to gain an external perspective on risks.	Gaining an external perspective on the clear prioritization of handling disruptions.

No	Program recommendation	Target
3	Add backup power supply lines for operational continuity.	Accelerating the availability of power sources during disruptions to minimize delays and the impact of blackouts.
4	Conduct education, training, and certification for station operational staff regarding TEF operations.	Enhance understanding and ensure the quality of repair and maintenance processes for TEF equipment.
5	Conduct an assessment of the SOPs in use.	Ensure that SOPs are updated in accordance with system changes.
6	Conduct regular evaluations of operational staff readiness.	Assess the level of readiness of staff in the station's operational processes.
7	Increase the dissemination of audit results to the smallest work units.	Ensure the equitable distribution of audit information.
8	Assess the ability of station operational staff to analyze potential disruptions as one of the criteria for rotation.	Mapping the capabilities of station operational staff.
9	Increase the frequency of training related to disruption analysis capabilities for station operational staff.	Ensure uniform disruption analysis capabilities among station operational staff.
10	Increase or expedite the process for having standby electrical personnel.	Accelerate response times during electrical power disruptions.
11	Find alternative suppliers capable of providing electrical power.	Alternative power sources.
12	Increase or upgrade the capacity of generators.	Operational readiness during electrical blackouts.
13	Build a power plant managed internally by the company.	Enhance the reliability of electrical power supply.
14	Increase the number of personnel overseeing repair and maintenance work.	Improve the quality of maintenance and repair work
15	Conduct regular certification of TEF equipment.	Ensure the operational suitability of equipment.
16	Increase the budget for training and certification of supervisors and technical staff for TEF	Ensure that competent personnel are evenly distributed across all maintenance and repair oversight

No	Program recommendation	Target
	maintenance and repair oversight.	roles.
17	Use CCTV technology as a tool for monitoring work processes.	Enhance the effectiveness of oversight processes for maintenance and repair activities.

DISCUSSION

HIRADC, following ISO 31000 and AS/NZ 4360 standards, offers a structured method for risk management. In TEF (Trackway Exhaust Fan) for MRT Jakarta's systems, it helps identify hazards, assess risks, and implement controls. For example, addressing risks like power disruptions or equipment maintenance by increasing generator capacity or enhancing staff training aligns with these standards, ensuring improved safety and operational reliability.

CONCLUSIONS AND RECOMMENDATIONS

Based on the risk management analysis of "TEF Operations for Trains and Underground Stations of Jakarta MRT," utilizing HIRADC aligned with AS/NZ 4360 and ISO 31000 standards, as well as fishbone diagrams and the 5 Whys analysis, it was concluded that 33 potential risks are associated with changes in TEF operations. Of these, 17 actions have been recommended to mitigate these risks. It was found that manual operation of TEF is currently more suitable due to a high-risk category identified in automated operations that requires further control.

To address the identified risks, if the company opts to continue with automated TEF operations, it must focus on minimizing risks related to power disruptions. Further analysis should be conducted on low and moderate-risk categories to prevent escalation and potentially eliminate them. If the proposed recommendations do not sufficiently lower risk levels, a re-evaluation with additional data from other informants is recommended.

FURTHER STUDY

Future studies should incorporate assessments from external parties or third-party evaluators to provide a broader perspective for risk analysis.

ACKNOWLEDGMENT

I would like to extend my heartfelt gratitude to all parties who supported the completion of this research. I am especially grateful to my advisors, informants, and PT MRT Jakarta for the valuable information provided in the name of scientific knowledge.

REFERENCES

- Cholil, A., & Santoso, Su. (2020). PENERAPAN METODE HIRADC SEBAGAI UPAYA PENCEGAHAN RISIKO. *Jurnal Bisnis & Manajemen*, 20(2).
- Izadi, T., Mehrabian, M. A., Sadrizadeh, S., Olofsson, U., & Abouali, O. (2022). The effect of ventilation system with and without under-platform exhaust on the concentration of braking micro-particles inside the subway system. *Tunnelling and Underground Space Technology*, 128. <https://doi.org/10.1016/j.tust.2022.104638>
- Long, Z., Yang, Y., Liu, C., & Zhong, M. (2021). Study on the optimal operation mode of ventilation system during metro double-island platform fire. *Building Simulation*, 14(3), 779–792. <https://doi.org/10.1007/s12273-020-0692-4>
- Mardiansyah, D., Wiwaha, G., & Jenderal Kementerian Keuangan, I. (2019). PENGGUNAAN MODEL RISK CONTROL MATRIX DALAM PELAKSANAAN AUDIT.
- Rahayu, N. A., & Santoso, S. (2021). Implementation of Six Sigma to Minimize Reject Gusset Difference and Fold in the Blowing Process. *European Journal of Business and Management Research*, 6(4), 1–6. <https://doi.org/10.24018/ejbm.2021.6.4.913>
- Santoso, S., Anjela, L., Alvionita, U., Firmansyah, F., Etlanda, K. A., & Fatmawati, A. A. (2021). The Role of Risk Management in Minimizing Black Stain Through the FMEA Approach at PT MPZ. *Jurnal Rekayasa Mesin*, 12(3), 733–745. <https://doi.org/10.21776/ub.jrm.2021.012.03.23>
- Santoso, S., Aulia, M. I., Harahap, R. S., Sitorus, R. S., & Waskita, D. S. (2021). Improvement of cooling time performance in TAD ® 20t mixing vessel using root cause analysis and PDCA cycle in TAD ® 20t mixing vessel product maturity . *IOP Conference Series: Materials Science and Engineering*, 1034(1), 012126. <https://doi.org/10.1088/1757-899x/1034/1/012126>
- Santoso, S., & Mayrifka, D. (2019). Analysis Problem and Improvement of Appearance Aesthetics Product Model HC C5 / XT with Method of Plan-Do-Check-Action (PDCA) In Pt. XXXX creating IK Casting Deburring Process, OPL (One Point Lecturer) Deburring Process & Final Casting, OPL Installation and Waiver Provisions and OPL Products Process Manual Process Baritori. In *International Journal of Innovative Science and Research Technology* (Vol. 4, Issue 11). www.ijisrt.com42
- Santoso, S., Wredo, M. J., Anggara, A., Anujuprana, H., Koordinator, K., Kemaritimian, B., Surya, A., Adhadi, W., Unggul, P., Aji, W., Ramadhani, M., Rian, M., Liliani, U., Nurahma, S., Rasya, S., Santoso, K., Nabila, A., & Penerbit, R. (2024). *KONSEPSI DAN TELAAH IMPLEMENTASI MANAJEMEN RISIKO PEMBANGUNAN NASIONAL LINTAS SEKTOR* (1st ed.). Kementerian Koordinator Bidang Kemaritimian dan Investasi.

- Santoso, Su., Rochman, & Fithri, P. (2020). Transformasi Digitalisasi Pelaporan HAZOB Untuk Meningkatkan Kinerja Keselamatan Kerja di Perusahaan. *Jurnal Sains, Teknologi Dan Industri*, 18(1), 11650.
- Seldon Magfiroh dan Rudi Wibowo, I., Studi Agribisnis, P., Pertanian, F., Jember Jalan Kalimantan, U., & Tegal Boto Jember Jawa Timur, K. (2019). Manajemen Risiko Rantai Pasok Tebu (Studi Kasus di PTPN X) Manajemen Risiko Rantai Pasok Tebu (Studi Kasus di PTPN X) The Supply Chain Risk Management of Sugarcane (Case Study in PTPN X). *Jurnal Pangan*, 28(3).
- Wen, Y., Leng, J., Shen, X., Han, G., Sun, L., & Yu, F. (2020). Environmental and health effects of ventilation in subway stations: A literature review. In *International Journal of Environmental Research and Public Health* (Vol. 17, Issue 3). MDPI AG. <https://doi.org/10.3390/ijerph17031084>