

Evaluation of Permit-to-Work System for Confined Spaces Using Value Stream Mapping and Root Cause Analysis

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Article Information	ABSTRACT
Article History Received : February 24, 2026 Revised : March 03, 2026 Published : April 04, 2026	The work permit system fulfills clause 6.1.5 in PP No. 50 of 2012 concerning Occupational Health and Safety Management Systems (SMK3) and is required for high-risk activities, such as hot work, confined space operations, work at height, and scaffolding operations. This research aims to analyze waste in the confined space work permit issuance process and determined the root causes. The methods employed are Value Stream Mapping (VSM), to map the permit issuance workflow and identify existing waste. Root Cause Analysis (RCA), to analyze the root causes of waste. The results illustrate process efficiency of the confined space permit issuance process through Future State Mapping and recommendations for potential improvements to reduce waste permit issuance process, prevent work delays and avoiding impediments to company productivity. The waste analysis results of the confined space permit issuance process using Value Stream Mapping (VSM) indicate that the Approval 1 stage is already categorized as Lean Enterprise, with a Process Cycle Efficiency (PCE) value > 30%. However, the Approval 2 and Approval 3 stages are still classified as Un-Lean Enterprise, with PCE values < 30%. Recommended improvements include developing a notification-based website system, prioritizing new permit submissions, enabling mobile approvals, refining the permit issuance SOP and online submission process.
Keywords: <i>Confined Space; Root Cause Analysis; Safety Management System; Value Stream Mapping Work Permit.</i>	

INTRODUCTION

Occupational Health and Safety (OHS) refers to effort aimed at protecting workers from the risks of workplace accidents and Occupational Diseases, in accordance with the provisions of Government Regulation (Peraturan Pemerintah) No. 50 of 2012. Based on data from the Indonesian Social Security Agency for Employment (BPJS Ketenagakerjaan) in 2021, there was a 5.6% increase in work accident cases, totaling 234,370 incidents, with 6,552 of these resulting in fatalities. This necessitated the disbursement of approximately Rp1.79 trillion in funds by BPJS Ketenagakerjaan. In efforts to reduce the number of workplace accidents, it is essential to implement a hierarchy of risk controls, such as elimination, substitution, engineering controls, administrative controls, and the use of Personal Protective Equipment (PPE) (Fandy D, 2022). At the stage of administrative control, one can implement safety documents like Job Safety Analysis (JSA), Hazard Identification, Risk Assessment, and Determining Controls (HIRADC), and the Occupational Health and Safety Management System (SMK3) (Ikhsan, 2025). As stipulated in Government Regulation (Peraturan Pemerintah) No. 50 of 2012, it is mandatory to have a work permit system for high-risk jobs (Criterion 6.1.5) and supervision of work execution (Criterion

6.2.1). These requirements are to be fulfilled through documented procedures to ensure that work is carried out safely, consistently, and in a well-organized manner (Sani et al, 2024).

The documented work permit procedure serves as a guideline for the authorization process of high-risk work. The primary objective of this procedure is to enhance safety and reduce the number of workplace accidents, as mandated by Government Regulation No. 50 of 2012. According to research by Febriyani et al. (2020), eight categories of high-risk work have been identified, including hot work, electrical work, work with radioactive materials, confined space entry, work at height, excavation, work in fire-prone areas, and lifting activities. Based on data from the Indonesian Social Security Agency for Employment (BPJS Ketenagakerjaan) in 2021, there were 7,298 accident incidents with 9,224 victims, including 33 cases of poisoning and 6 cases of Occupational Diseases, most of which occurred during the execution of high-risk work. This data underscores the critical importance of implementing a work permit procedure to reduce the incidence of accidents and occupational illnesses. In the food industry sector, five types of work permits are typically implemented: for hot work, confined space entry, excavation, work at height, and scaffolding use. The absence of a work permit increases the risk of accidents, as evidenced by the research of Elya Widarti (2015), which reported an explosion and burn injuries resulting from work performed without a permit. Furthermore, advancements in information technology now play a crucial role in improving the efficiency, accuracy, and ease of data access, as explained by Balqis et al. (2024) and Dhany Sembiring in their respective studies.

Preliminary observations indicate a significant discrepancy between the number of work permits issued and those inspected during the January–July 2024 period. To illustrate, in March 2024, 133 work permits were issued, but only 31 were inspected. Meanwhile, in July 2024, out of 112 work permits, only 3 were inspected. The minimal execution of inspections poses a serious issue, as inspections aim to detect potential hazards or unsafe acts and implement immediate corrections before accidents occur (Ibrahim & Hendrasarie, 2022). Without adequate inspection, the risk of accidents such as sparking, fires, explosions, impacts, falls, gas poisoning, and electric shocks increases significantly (Kementerian Ketenagakerjaan, 2022).

Comparison between the number of issued work permits and those that have been inspected indicates that the work permit issuance process has not yet reached an optimal level. A process is considered to contain waste if its final outcome is not achieved (Walenna et al., 2018). In the same study, Gaspersz and Fontana identified seven types of waste: overproduction, waiting, transportation, inefficient processes, excess inventory, unnecessary motion, and product defects (Ngerndee et al, 2022). Therefore, analysis is required to identify the sources of waste in the confined space work permit issuance process. To uncover the causes of this failure to achieve the desired output, a method capable of detecting inefficiencies in the confined space work permit information system is needed. The lean approach can be used to enhance efficiency and eliminate waste in the workflow (Arunizal et al., 2024). One of the tools from the lean approach to be applied in this study is Value Stream Mapping (VSM), which functions to visualize and map the flow of both value and information throughout the process from start to finish (Primajaya et al., 2022). VSM will identify activities that add value (Value Added) (Hasanah et al, 2023) and those that do not (Non-Value Added) (Kusuma & Hasibuan, 2022). VSM consists of two main stages: Current State Mapping (CSM) and Future State Mapping (FSM) (Yusran et al, 2023).

After waste in the work permit issuance process flow is identified, an in-depth root cause analysis is subsequently conducted using the Root Cause Analysis (RCA) method with a fishbone diagram model. RCA is a systematic method for identifying the fundamental cause of a problem (Luckyta & Partiw, 2012). The fishbone diagram is used to map eight causal factors: man, method, machine, material, measurement, environment, management, and maintenance (Pušnik et al., 2019). The integration of Value Stream Mapping (VSM) and Root Cause Analysis (RCA) methods is expected to effectively identify waste and enhance the efficiency of the confined space work permit process. This evaluation will ultimately yield recommendations based on Future State Mapping (FSM) and the root cause analysis from RCA (Lwin et al, 2022). These recommendations are aimed at improving workflow effectiveness, reducing waste, and strengthening the responsibility of area owners for work conducted within their respective areas (Yanti et al, 2022).

The purpose of the research is evaluating the effectiveness of the existing work permit and giving the best recommendations using value stream mapping method.

RESEARCH METHODS

The research methodology applied in this study consists of a series of stages undertaken to complete the research. Value Stream Mapping is a lean tool used to visualize the flow of materials and information in order to identify waste and improve process efficiency. Below are the systematic stages of applying VSM :

1. Collecting the primary and secondary data
2. Create the current state map
3. Analyze and identify waste
4. Develop the future state map

Primary data was obtained directly through interviews with expert judges who hold the authority to approve work permits such as safety officer, safety manager, and operator. Secondary data was sourced from Safety Work Permit and Inspection (SWPI) records for the period of January to July 2024 including timestamp, record of submission, review, approval, revision, and completion stages from the websites. Data processing and analysis were conducted using the Value Stream Mapping (VSM) and Root Cause Analysis (RCA) methods. The Value Stream Mapping (VSM) method was based on its capability to identify and categorize end-to-end process activities that constitute waste. The Root Cause Analysis (RCA) method was applied to determine the root causes of this waste and to provide recommendations for making the work permit issuance process more efficient.

RESULTS AND DISCUSSION

The analysis of the confined space work permit issuance process was conducted using Value Stream Mapping (VSM) focuses on the process flow time at each approval stage. Previous research was conduct to make the approval of work permit more efficient by using website (Maulana et al, 2024). The implementation of work permit website yet still took a long time. According to the workflow of the work permit issuance information system using the SWPI website, the permit issuance process consists of three sequential approval stages performed by respective area approvers. The following is a recap of the confined space work permit submission times during the observation period.

Tabel 1. Recap of Confined Space Work Permit Submission Times Based on the SWPI Website

Job Description	Submission Date	Work Date	Submission time	Approval 1 (time)	Approval 2 (time)	Approval 3 (time)	Barcode Available
Cleaning of cones silo 202 and 502	27/05/2024	27/05/2024	07.22 (27/05/2024)	07.31 (27/05/2024)	08.21 (27/05/2024)	11.45 (27/05/2024)	✓
Cleaning of cones silo 402 and 406	21/06/2024	21/06/2024	07.00 (21/06/2024)	07.10 (21/06/2024)	07.41 (21/06/2024)	12.03 (21/06/2024)	✓
Cleaning of cones silo 414	01/08/2024	01/08/2024	07.44 (01/08/2024)	07.53 (01/08/2024)	10.36 (01/08/2024)	17.02 (01/08/2024)	✓
Cleaning of cones silo 203, 504, 602	29/08/2024	29/08/2024	07.21 (29/08/2024)	07.30 (29/08/2024)	07.31 (29/08/2024)	08.11 (29/08/2024)	✓

Cleaning of cones silo 213, 215, 313	25/09/ 2024	25/09/ 2024	07.31 (25/09/2024)	07.48 (25/09/2024)	07.54 (25/09/2024)	10.57 (25/09/2024)	✓
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After compiling the submission times for confined space work permits, the next step involves calculating the duration required at each approval stage by the respective approvers. This calculation aims to determine the amount of time spent in reviewing and approving the permits at every level of the workflow. By measuring the duration of each approval stage, a clearer understanding of time distribution within the permit issuance process can be obtained. The following section presents the compiled results of approval durations for confined space work permits during the observed period.

Tabel 2. Recap of Approval Durations for Confined Space Work Permits

Job Description	Approval 1 (minute)	Approval 2 (Minute)	Approval 3 (Minute)
Calculation Example	Submission – Approval 1	Approval 1 – Approval 2	Approval 2 – Approval 3
Cleaning of cones silo 202 and 502	9	50	204
Cleaning of cones silo 402 and 406	10	31	4.582
Cleaning of cones silo 414	9	163	6.146
Cleaning of cones silo 203, 504, 602	9	1	1.480
Cleaning of cones silo 213, 215, 313	17	6	3.063
Average of cycle time	10,8	50,2	3,095

After obtaining the average approval duration from the approvers, the next step is to classify the time types according to Value Stream Mapping (VSM) framework, namely Cycle Time (CT), Waiting Time (WT), Value Added (VA), and Non-Value Added (NVA). This classification is calculated based on the results from Table 4.9. The Value Added (VA) value has been predetermined by the company, which sets a maximum duration of 15 minutes for each approval stage.

a. Value Added (VA)

$$VA \text{ Ratio} = \frac{\text{value added time (process time)}}{\text{total process cycle time}} \times 100\% = \quad (1)$$

$$\text{1st VA Ratio} = 10,8 / 10,8 \times 100\% = 100\%$$

$$\text{2nd VA Ratio} = 15 / 50,2 \times 100\% = 29,88\%$$

$$\text{3rd VA Ratio} = 15 / 3.095 \times 100\% = 0,48\%$$

b. Non-Value Added

$$NVA = 100\% - VA(\%) = \quad (2)$$

$$\text{1st NVA} = 100\% - 100\% = 0\%$$

$$\text{2nd NVA} = 100\% - 29,88\% = 70,12\%$$

$$\text{3rd NVA} = 100\% - 0,48\% = 99,52\%$$

c. Waiting Time (WT)

$$\text{Waiting Time} = \text{Cycle Time} - \text{Value Added Time} = \quad (3)$$

$$\text{1st WT} = 10,8 - 10,8 = 0 \text{ minute}$$

$$\text{2nd WT} = 50,2 - 15 = 35,2 \text{ minute}$$

$$3rd\ WT = 3.095 - 15 = 3.080\ minute$$

d. Lead Time (LT)

$$LT = \sum CT \quad (4)$$

$$LT = 10,8 + 50,2 + 3.095 = 3.156\ minute$$

e. Total Waiting Time (TWT)

$$TWT = \sum WT \quad (5)$$

$$TWT = \sum WT = 0 + 35,2 + 3.080 = 3.115,2\ minute$$

f. Process Cycle Time (PCE)

$$PCE = \frac{Value\ Added\ Time}{Cycle\ Time} \times 100\% = \quad (6)$$

$$1st\ PCE = \frac{10,8}{10,8} \times 100\% = 100\%$$

$$2nd\ PCE = \frac{15}{50,2} \times 100\% = 29,88\%$$

$$3rd\ PCE = \frac{15}{3.095} \times 100\% = 0,48\%$$

Tabel 3. Time Classification According to VSM for Confined Space Work Permits

Which Approval	VA (%)	NVA (%)	Waiting Time (minute)
Calculation Example	100%	100% - VA (%)	CT - VA Time
1	100	0	0
2	29,88	70,12	35,2
3	0,48	99,52	3.080

Based on the calculations performed, the Lead Time (LT) was determined to be 3,156 minutes and the Total Waiting Time (TWT) was 3,115.2 minutes. The following are the results of the Value Stream Mapping for the confined space work permit.

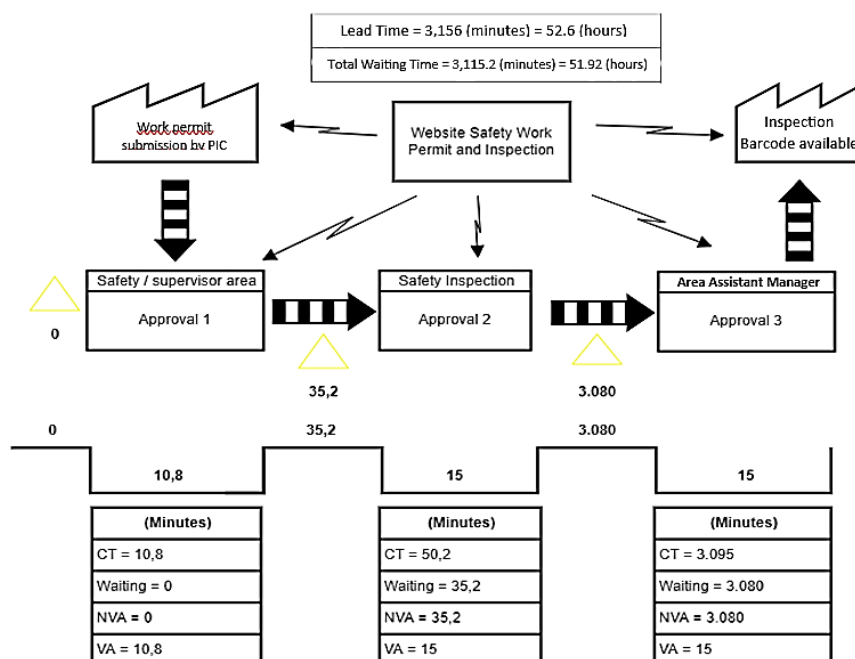


Figure 1. Current State Mapping of Confined Space Work Permit

The results of the Current State Mapping (CSM) for the confined space work permit show Value Added Ratio (VAR) values of 100% for Approval 1, 29.88% for Approval 2, and 0.48% for Approval 3. According to Gasperz, a process can be classified as a Lean Enterprise, meaning it has minimal waste, if its Process Cycle Efficiency (PCE) is greater than 30%. The obtained results indicate that the Approval 2 and Approval 3 stages are categorized as Un-Lean Enterprise, as their PCE values are below 30%

From the Value Stream Mapping (VSM) analysis, time waste was identified in several work permit approval stages, with the most significant delays occurring in Approval 2 conducted by the Safety Inspector and Approval 3 conducted by the Asisstand Manager. These stages were found to contribute substantially to the overall waiting time within permit issuance cycle. To identify the root causes, an analysis was conducted using the RCA method through interviews with the Safety Inspector and the area's Assistant Manager. The purpose of these interviews was to obtain detailed information into operational constraints, workflow challenges, and other contributing factors that may not be directly visible from system data. The results of these interviews were the used as the basis for constructing a fishbone diagram. The following is the fishbone diagram derived from the interview with the Approval 2 authority.

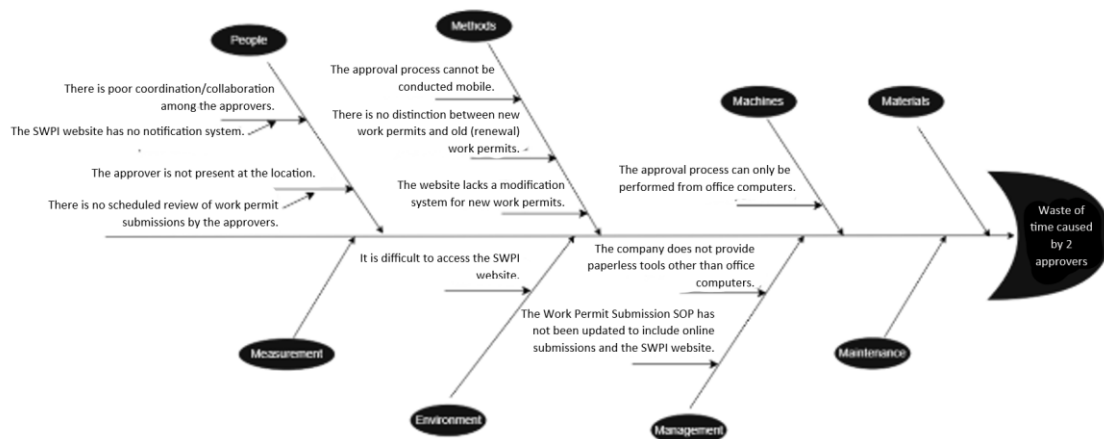


Figure 2. Fishbone Diagram of Time Waste for Approval 2

Furthermore, the analysis using Value Stream Mapping (VSM) also revealed time waste in the approval stage conducted by Approval 3, represented by the asisstant Manager. The following is the fishbone diagram derived from the interview with Approval 3.

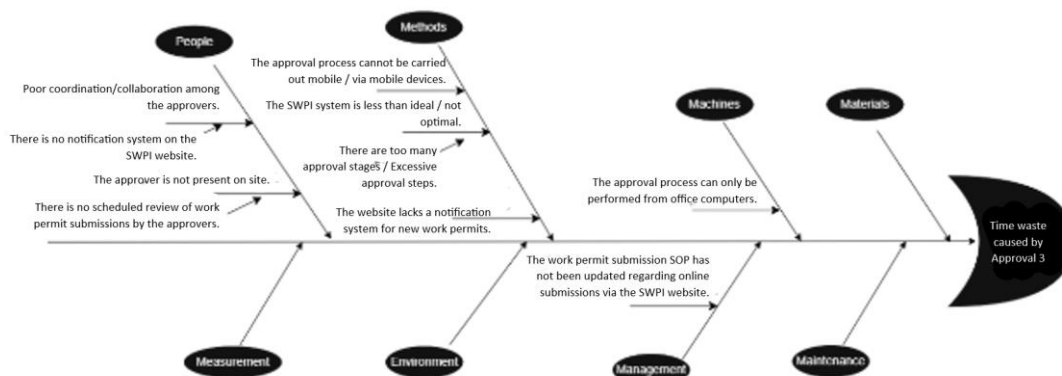


Figure 3. Fishbone Diagram of Time Waste for Approval 3

The second step of VSM, Future State Mapping (FSM), is used to illustrate recommendations for improving the information system workflow for confined space work permit issuance. These improvement recommendations are based on the constraint analysis results from

the RCA method. The following section presents the recommendations action that can be implemented to reduce/eliminate the time waste occurring in the Approval 2 and Approval 3 stages.

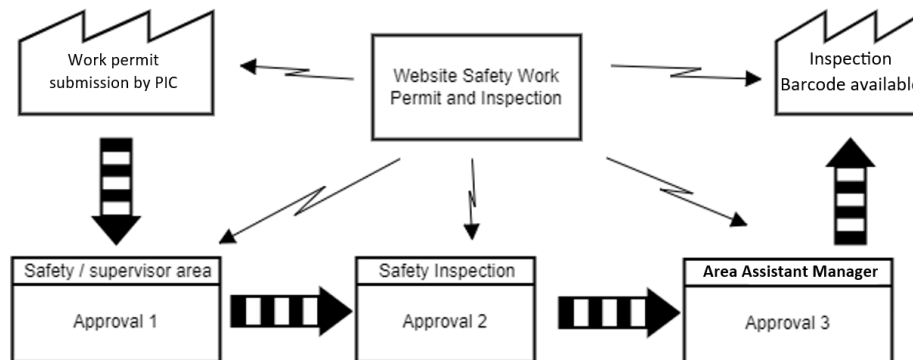


Figure 4. Future State Mapping for Work Permit Issuance

The Future State Mapping (FSM) for the confined space work permit system retains the three approval stages: from the area safety personnel/area supervisor, followed safety inspector, and finally the assistant manager. To reduce waste identified in the current state analysis, the proposed improvement recommendations focus on enhancing the functionality of the SWPI website. The improvement include by adding notification features to alert approvers of new or pending permit submissions, the implementation of a permit prioritization system to distinguish urgent permits from routine submissions, and the enabling of a mobile-based approval process to increase flexibility and responsiveness. These measures are intended to reduce waiting time between approval stages and improve overall workflow continuity.

Furthermore, the Standard Operating Procedure (SOP) for permit issuance can be refined by incorporating a structured schedule for checking new permits on the SWPI website and revising the workflow for online permit submissions. It is expected that through the implementation of these recommendations, the Process Cycle Efficiency (PCE) value will increase to above 30%. Consequently, the work permit information system will meet the criteria of Lean Enterprise, with waste having been significantly minimized.

CONCLUSION

The results of the waste analysis for the confined space work permit process, conducted using the Value Stream Mapping (VSM) method, indicate that the Approval 1 stage is already classified as a Lean Enterprise. This is evidenced by a Process Cycle Efficiency (PCE) value of >30%, signifying that waste has been minimized at this stage. However, the Approval 2 and Approval 3 stages are still categorized as Un-Lean Enterprise, with PCE values below 30%. This finding necessitated a further, in-depth analysis using Root Cause Analysis (RCA). The proposed improvements include website development featuring a notification system, prioritization of new work permits, and enabling a mobile approval process. Additionally, it is recommended to refine the Standard Operating Procedure (SOP) for work permit issuance and optimize the online submission process.

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