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EXAMINING FACTORY PROCESS SAFETY MANAGEMENT SYSTEMS AND STUDYING LEAN IMPROVEMENT METHODS

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ABSTRACT
Many factories have set up a safety management system (PSM), and there is an increasing rate of safety management systems. This is increasingly in line with the development of industrial plants. External and internal inspection of security management processes are the core of Process Safety Management (PSM) and are an essential opportunity to improve operational solutions. The problems of security inspection arise due to unclear and unplanned inspection issues, resulting in unsystematic monitoring of factual information and opinions and loss of opportunities to achieve goals throughout the organization. This research aims to improve the inspection process by using computer software technology in auditing. After improving the process according to the Lean Process Management (ECRS) concept to reduce waste, the workflow was reduced by 40.74%, and 60% efficiency was increased. In addition, the assessment results from a sample of PSM auditors showed 93.4% satisfaction as the most appropriate. Therefore, this study demonstrated the potential and benefits of implementing the Process Safety Management System (PSM) audit program and applying Lean theory to improve auditing, which can be used as an essential reference for future research and program development.
Keywords: *Lean Inspection Process, Factory Certification Program, Factory Inspection, Factory Risk Assessment*

1. Introduction

1.1 Introduce the Problem

Currently, factories have production processes and activities related to hazardous chemicals, flammable gases, and flammable liquids that are at risk of severe accidents to varying degrees and tend to increase continuously with the number of factories (Department of Industrial Works, 2020). Serious accidents from the production process include explosions, fires, and spills of hazardous chemicals affecting operators, the community, the environment, and property. It is based on incidents of dangerous chemical spills, gases, and flammable liquids from the production process. According to the International Laboure Organization (ILO), inadequate workplace safety and health procedures have resulted in an estimated 2.78 million deaths and 374 million non-fatal injuries (Noman et al., 2021). In addition, establishments must be more mindful of occupational health risks and safety (Zielinski Nguyen Ajslev & Elisabeth Ejstrup Nimb, 2022).

Currently, inspection safety issues, with compliance with the law (Dwiasnati & Hidayat, 2022), (Slezak et al., 2020) are not effective enough, so it is necessary to find dangerous points in the work process (Halvani & Sahraee, 2020), (Rudakov et al., 2021) and find measures to control and prevent hazards or accidents in those activities (Ghasemi et al., 2023), (Rodrigues et al, 2021) correctly. According to statistics, complaints from non-compliance with factory control laws were recorded at an average of 3,973 complaints per year and 1.07 complaints per factory (Wang et al., 2021). Such complaints affect the environment and the community (Manservisi et al, 2023). It is not likely to decrease significantly, even though the factory has a safety audit and analysis of the risk of impacts (Badoozadeh et al, 2021), (Rudakov et al., 2021).

Risk management for Factories where hazardous substances are used, Process Safety Management (PSM) is at the core of management, and a company's internal and external

inspection processes are essential to its implementation (Hazzan, et al.,2022). For problems in inspecting factories in the process of operating according to the system, follow PSM. It also found that there was a delay. The inspection content needs to be more comprehensive according to the requirements, which is an inefficient inspection (Tepparit & Am-Eam, 2023), (Amor & Dimyadi, 2021). It was found that problems with inspectors' qualifications and inspection methods are also the main factors in inadequate inspections. Some inspections overlook essential safety issues or lack a way to identify specific problems, sticking to document systems rather than practicalities and operational risks or reinterpreting safety concerns as non-safety issues. It also includes non-compliance with standards that must be inspected (Hutchinson et al., 2024b, 2024a). Therefore, the researcher improved the integrated system assessment method as a new body of knowledge for monitoring and computer technology. Designing an inspection program to evaluate process safety management by considering compliance with plant control laws to enhance inspection efficiency in evaluating according to the requirements of process safety management operations. The inspection process is based on the PSM system.

1.2 Research Conceptual Framework of the Study

Studying legal requirements and verifying relevant research establishes a research conceptual framework. Research Conceptual Framework to improve the inspection process using the Lean concept to create excellence in various methods. The goal is to reduce lead time, reduce waste in inspections, and reduce waste as well as Non-Value-Added Activities (NVA), as shown in Figure 1.

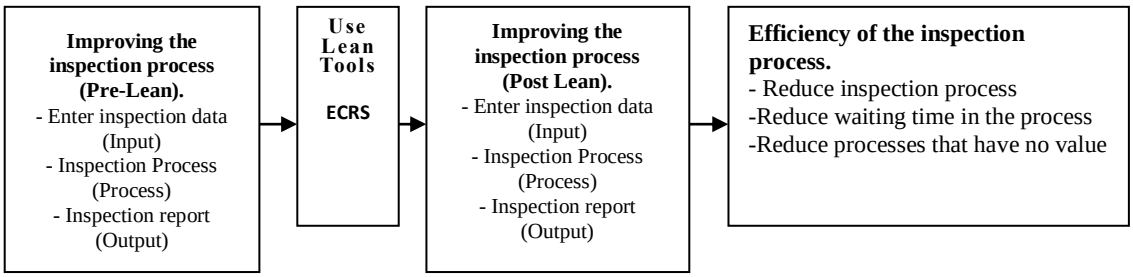

Fig. 1. Research Conceptual Framework

2. Literature Review

Preparation of risk management reports for factories where hazardous substances are used. It will consist of a report on the analysis of risks from hazards arising from factory operations and safety management. Safety management is divided into two components as follows.

2.1 Safety Management System (SMS)

Safety Management System (SMS) is a systematic process for managing security. It defines responsibilities and establishes policies and practices for managing an organization's security. The components of the security management system can be understood as shown in Table 1(Kešeľová et al., 2021).

Table 1 - Safety Management System Framework: 4 Components and 12 Elements by ICAO.

Safety Policy and Objective	Safety Risk Management	Safety Assurance	Safety promotion
Management commitment &responsibility	Safety risk assessment mitigation	Safety performance Monitoring Measurement	Training and education
Safety accountabilities Appointment of key safety person personnel Coordination of ERP SMS documentation	Hazard identification	Management of Change Continuous improvement and audit	Safety communication

The importance of SMS in the most practical and efficient way of allocating security resources has been highlighted in recent research (Chen et al., 2023), (Zhang et al., 2023). It has

been found that the working conditions of employees have improved significantly in the field of SMS and also promote a safety culture that rewards responsible attitudes and behaviors (Manservisi et al., 2023), (Nwankwo et al., 2020). These cultural changes are necessary to improve the general safety climate of the organization and increase the number of people affected by the organization's safety. The effectiveness of process safety management systems (PSMs), such as reducing industrial accidents in South Korea, was also highlighted in this research (Saleem & Malik, 2022), (Yoo & Shim, 2023). The study indicated that SMEs with fewer employees, 100 people, are at higher risk than large companies. This study emphasizes that audit results with low scores have a high chance, so there is an urgent need to improve the system. PSM and Management Techniques to Stop Industrial Accidents (Yoo & Shim, 2023). Other examples of integrating digital technologies to support safety include creating a work permit management system in model-based petrochemical construction. This practice is in line with a broader industry trend that focuses on continuous development to promote a safety culture (Bai et al., 2023), (Chen et al., 2023), (Siuta et al., 2022).

2.2 Process Safety Management (PSM)

Process Safety Management (PSM) is the management of safety and the prevention of incidents and injuries related to production processes where hazardous chemicals are used. It uses management measures and an engineering basis to identify, evaluate, and control hazards from production processes, including storage, design, use, production, maintenance, inspection, testing, and transportation or movement of highly hazardous chemicals (Moore et al., 2015). The scope of PSM system assignments to industrial facilities includes (1) processes involving highly hazardous chemicals in quantities in possession at any given time equal to or greater than the prescribed amounts and (2) processes involving flammable gases or flammable liquids with a possession volume of 4,545 kilograms or 10,000 pounds or more at any given time (Industrial Estate Authority of Thailand Board, 2016). At present, research and development of various IoT technologies to manage multiple types of hazards, such as those related to the safety of factories and workers, usually affect the level of protection, especially in the process industry. The proposed system applications range from periodic scheduled maintenance monitoring and analysis of the age of the equipment from processing or packing hazardous materials to remotely monitoring the dangerous conditions of workers (Gnoni et al., 2020), (Sundaram & Zeid, 2023), (Tang, 2021).

A Process Safety Management System (PSM) inspection is a factory audit based on internal inspection principles (Guo, 2023). Nowadays, inspecting security management systems has become more critical because it is the expectation of success in implementing a system. The PSM and inspection are essential opportunities to monitor processes and improve efficiency. Most inspection processes deal with PSM systems from a complete approach. Regardless of the actual inspection design of the management system or the organization's goals. Inspection is more effective if it aligns with the design and objectives of the organization. In addition, an exemplary system audit must have an effective Process Safety (PS) team to assess and analyze hazards and provide appropriate control solutions (Behie et al., 2020), (Badoozadeh et al., 2021). The inspection must be carried out using the Process Safety Assessment Checklist based on 14 basic elements, as shown in Table 2 (Amyotte&Lupien, 2017), (Kumar, 2024)

Table 2 - Process Safety Assessment Checklist by Basic Components.

PSM Inspection issues	
1.Employee Participation	8. Mechanical Integrity
2. Process Safety Information	9. Hot Work Permit and Non-routine Work Permit)
3. Process Hazard Analysis (PHA)	10. Management of Change
4 Operating Procedures	11. Incident Investigation
5.Training	12. Emergency Planning and Response
6. Contractor Management	13. Compliance Audits
7. Pre-startup Safety Review	14. Trade Secrets

The inspection process will improve to maximize efficiency. The Lean concept is used to reduce waste in every inspection process, emphasizing maximum effectiveness and loss reduction by focusing on flow (Saleem & Malik, 2022) such as improving safety work processes in offshore oil and gas exploration and production (Yeshitila et al, 2021) or reducing

risk steps according to ergonomic principles of work (Tortorella et al., 2020), (Dieste et al., n.d.) etc. Implementing lean systems to improve audit processes (Elattar et al., 2020), (Marques et al., 2021), (Di Natali et al., 2023), such as organizational leadership, must be multi-dimensional and integrated. Personnel Communication Technical problems (pulling system) External factors to reduce obstacles to making a lean system (Araújo et al., 2021). The Lean inspection process consists of five steps.

2.2.1 Value Definition

This step analyses waste from the current condition, which deals with waste from the process and is regarded as an essential value-creation process. Therefore, the types of Muda (8 Waste) include 1) Overproduction, 2) Waiting, 3) Transportation, 4) Non-Value-Added Processing, 5) Excess Inventory, 6) Defects, 7) Excessive movement, and 8) non-utilized talent, must be eliminated for the process to be effective (Dobrowolski et al., 2022), (Leksic et al., 2020), (Markowski et al., 2021)

2.2.2 Value Stream Analysis

The analysis starts with a diagram of the process of receiving orders and the factory to be inspected. That allows for identifying critical or problematic steps in the supply chain. For example, it identifies bottlenecks and fault points, which can now be provided in the Systems Dynamics (SD) format, as a model that helps to analyze the improvement points effectively (Arey et al., 2020), (Assis et al, 2021). It then plans the inspection (Plan) and the inspection (Do) according to the specified topics. Finally, it checks the results against the law in terms of accuracy and duration of inspection (Check), after which the report is printed or corrected (Action) in accordance with the Quality Management Principles (PDCA).

2.2.3 Flow

The workflow along the steps of the job-by-job review process will be characterized as a One-Job Flow, which must be fast and done by removing obstacles and distances between the work stages, a waste associated with all investigations.

2.2.4 Pull/just in time

The concept of factory inspection must be carried out only in accordance with the requirements related to the law that requires inspection. This means checking according to the checklist as required by law, which will not cause waste in the inspection process. Also, there are plans or monitoring tools that can reduce waste.

2.2.5 Perfection

Perfection should come from efficient work, which reduces time, processes, and errors associated with factory inspection (Aucasime-Gonzales et al., 2020). This research focuses on One-Stop inspection by designing the RU Program for industrial inspection. It focuses on applying Lean concepts to maximize the value of work entirely.

3. Research Methods

Steps for improving factory inspection methods based on Lean concepts (Virtanen, n.d.-a, n.d.-b; Wang et al., 2021) are as follows.

3.1 Analyses the current condition of factory inspection.

The researcher brought up the problem of ineffective factory inspection for safety management systems. Brainstorm meetings with experts specialising in safety inspection involved analysing the wastes of the current inspection process and summarising them in problem analysis to make improvements by ECRS principles (Jordaan, n.d.; Kanoksirirujisaya, 2022), (Pertiwi & Astuti, 2020), as shown in Table 3.

Table 3 - Summary of inspection processes and waste analysis of current methods.

Step*s*	Inspection defined	8 Waste	VA/	**Current model**

		"DOWNTIME"	NVA	
1. Define scope and criteria.	It is to define the scope and rules of inspection, such as opening and closing the system, the ERA plan, OSHA *1910.119*, EPA *40* CFR *68* or ANSI/ISA *84* standards, etc.	D=Data Error/Coordination W=Waiting Verification E=Hard Verification Methods N=Nonqualified	NVA VA NVA	1.1 Check the status of current work and pending work plans. 1.2 Identify the inspection plan and coordinate with the examination recipients. 1.3 Prepare data sheets and prepare the necessary tools or equipment.
2. Check documents and records.	It involves reviewing supporting documents and records, including process security information (PSI) such as process flowcharts, material safety data sheets, and Process Hazard Analyses (PHA), etc.	D=Data Error/Coordination E=Hard Verification Methods M=Search Information/Document	NVA NVA VA NVA	2.1 Check general information 2.2 Select the topic to review. 2.3 Examine documents and records related to the process by referring to relevant documents. 2.4 Record the inspection results in the inspection form.
3. Conduct interviews and observations.	It is an interview and operational observation with a person who uses PSM, such as an operator, manager, engineer, or maintenance personnel, etc.	D=Data Error/Coordination N=Nonqualified E=Hard Verification Methods M=Search Information/Document	VA VA VA NVA	3.1 Check general information 3.2 Select the topic to review. 3.3 Interview and observe the work of related employees by searching for references according to relevant documents. 3.4 Record the inspection results in the inspection form.
4. Evaluate results and findings.	It evaluates the examination results and findings and compares the operation process's actual performance with the expected performance according to the scope, rules, and risks.	D=Data Error/Coordination M=Search Information/Document N=Nonqualified E=Hard Verification Methods N=Nonqualified	NVA NVA NVA	4.1 Evaluate inspection results 4.2 Identify inspection findings and compare them with standards or rules. 4.3 Prepare inspection reports and corrective guidelines, then submit them to relevant departments.
5. Follow instructions and actions.	A corrective and preventive action plan (CAPA) should be prepared in accordance with the *5*W-*2*H requirements to implement the recommendations and actions resulting from the assessment.	D=Data Error/Coordination W=Waiting Recommendation N=Nonqualified E=Hard Verification Methods	NVA VA VA	5.1 Finding ways to improve. 5.2 Prepare a Corrective and Preventive Action Plan (CAPA). 5.3 Make bug fixes following the suggestions.
6. Improvement of operation processes continuously.	It is a continuous improvement process based on feedback, learning, and workplace changes. In addition, the impact of operational procedures on PSM performance indicators should be evaluated.	D = Data Error/Coordination W = Waiting Recommendation N = Nonqualified E = Hard Verification Methods	NVA NVA VA	6.1 Find measures to prevent the recurrence of problems. 6.2 Find ways to control and amplify results. 6.3 Specify the measures according to clauses *6.1* and *6.2*.

Note: Refers to the topic of waste.
D =Defect, O=Over production, W=Waiting, N=Non-Utilized Talent, T=Transportation, I=Inventory, M=Motion, E= Extra-Processing
NVA =Non-Value-Added Activities, VA= Value Added Activities

3.2 Plan to work systematically to set goals for work improvement and guidelines for work improvement.

In this step, the researcher collected data to write the process of Lean (current value stream mapping) is as follows.

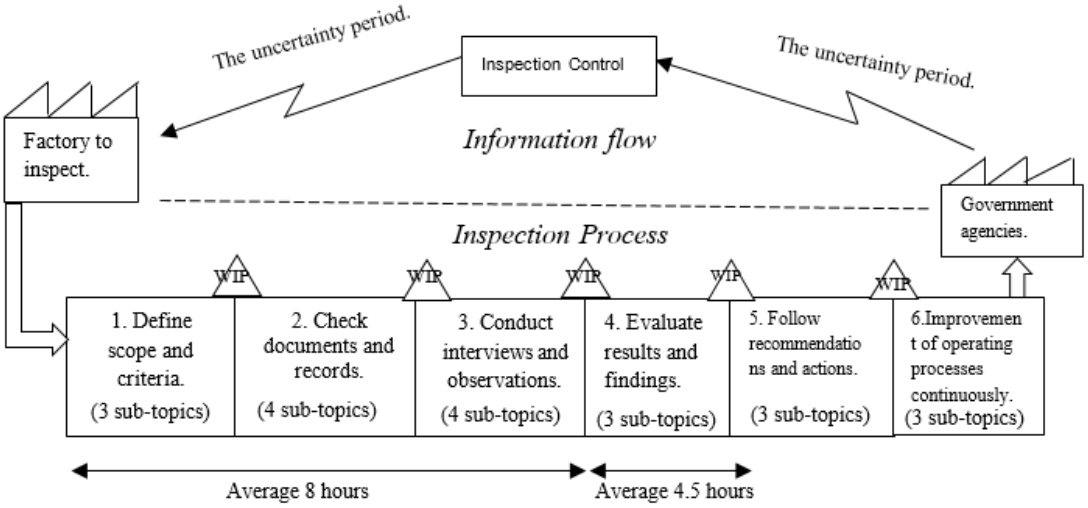

Fig. 2. The value stream mapping before improving Lean.

3.3 The design of the improvement process using the factory inspection program.

3.3.1 Designing and creating a PSM system inspection program.

Study the problems and needs of users for the program design from the questionnaire of the samples, together concerning the factory inspection report form a document titled Reporting Compliance of the Department of Industrial Works. Then, used to design the program can be written as the program's scope of work (Sundaram & Zeid, 2023). The RU Program for Industrial Inspection details the work system in Figure 3.

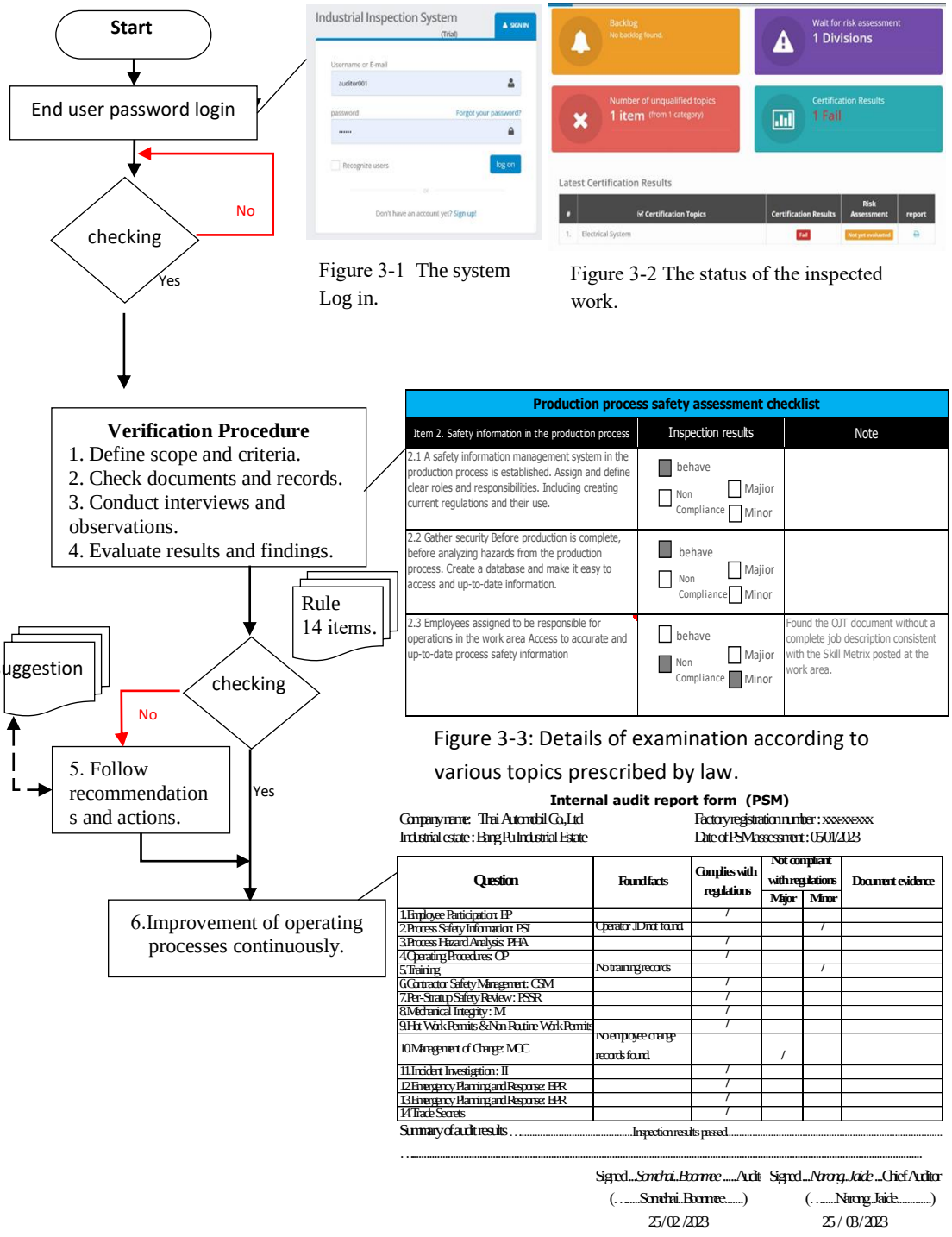

Figure 3-1 The system Log in.

Figure 3-2 The status of the inspected work.

Figure 3-3: Details of examination according to various topics prescribed by law.

Figure 3-4 The factory inspection report.

Fig. 3. The inspection process flowchart and inspection screen at each stage.

3.3.2 Evaluation of satisfaction using the program

For the assessment of satisfaction in using the program, a rating scale was used with a sample of factories and private auditors to assess satisfaction with the program. Data were collected from a sample of 50 factories out of 180 at-risk factories using the rating scale, which has five satisfaction evaluation criteria (excellent, good, moderate, fair, and poor).

4. Results and Discussions

Improving Processes by Reducing 8 Waste with ECRS Method (Wang et al., 2021), (Yoo & Shim, 2023). While designing and developing programs, the researcher revised the factory inspection methods using the ECRS improvement principle, resulting in reduced inspection and reporting processes. In addition, the new inspection processes, which use a factory inspection program, were compared with the current manual work. Table 4 summarizes the comparison results.

Table 4 - Summary table of root causes of problems with programmatic improvement guidelines

Steps	Current model	ECRS concept	Using the program
1.Define scope and criteria.	1.1 Check the status of current work and pending work plans. 1.2 Identify the inspection plan and coordinate with the examination recipients. 1.3 Prepare data sheets and prepare the necessary tools or equipment.	Display the status of tasks and monitoring plans on the screen (Combine) in a visual control manner with appointments to check and add the function to the list of tools or devices used (Simplify).	1.1 Check backlog status 1.2 Identify the inspection plan and list the necessary tools or equipment.
2.Check documents and records.	2.1 Check general information 2.2 Select the topic to review. 2.3 Examine documents and records related to the process by referring to relevant documents. 2.4 Record the inspection results in the inspection form.	General information about the plant and the topics of the inspection in the system are displayed on the screen (Combine), and the inspection results are recorded in the system inspection form (Simplify/Eliminate).	2.1Checking follows the list in the program. 2.2 Record the results in the program.
3.Conduct interviews and observations.	3.1 Check general information 3.2 Select the topic to review. 3.3 Interview and observe the work of related employees by searching for references according to relevant documents. 3.4 Record the inspection results in the inspection form.	General information about the plant and the topics of the interview/observation in the system on the screen (Combine) with a Link: Search for reference documents and check and save the results in the form through the system (Simplify/Eliminate).	3.1Checking follows the list in the program. 3.2 Interview and observe the work, then record the results in the program.
4.Evaluate results and findings.	4.1 Evaluate inspection results 4.2 Identify inspection findings and compare them with standards or rules. 4.3 Prepare inspection reports and corrective guidelines, then submit them to relevant departments.	Evaluate the results in the system by being able to link to reference standards and choose the function of printing the test report immediately (Combine/ Simplify).	4.1 Evaluate the results of an inspection program. 4.2 Prepare inspection reports and corrective solutions, then record them in the program.
5.Follow recommendations and actions.	5.1 Finding ways to improve. 5.2 Prepare a Corrective and Preventive Action Plan (CAPA). 5.3 Make bug fixes following the suggestions.	Select the link to find the improvement method according to the instructions in the system and choose to make an action plan in the system (Combine/ Simplify).	5.1 Prepare a Corrective and Preventive Action Plan (CAPA). 5.2 Make bug fixes following the suggestions.
6.Improvement of operating processes continuously.	6.1 Find measures to prevent the recurrence of problems. 6.2 Find ways to control and amplify results. 6.3 Specify the measures according to clauses 6.1 and 6.2.	Select the link for preventive measures and specify the control method in the system (Combine/ Simplify).	6.1 Identify measures to prevent the recurrence of problems besides control and report results.

A comparison of time before using the inspection program (Pre-Lean) and after using the inspection program (post-Lean), is shown in Table 5.

Table 5 - Summarizes the process of lean improvement with the ECRS technique.

Inspection and reporting procedures	**1.** Define scope and criteria.	**2.** Check documents and records.	**3.** Conduct interviews and observations.	**4.** Evaluate results and	**5.** Follow recommendations and actions.	**6.**Improvement of operating processes continuously.

			findings.			
Before using the program	3	3	4	3	3	3
After using the program	2	2	2	2	1	1

Summary of program usage results	Before using the program	After using the program	Productivity Up
All examination procedures	19 steps	10 steps	Up 40.74 %
Reduced time in the reporting section.	Average 12.5 hrs.	Average 5 hrs.	Up 60%

In this process, the researcher collected data to write the operations after Lean (Further Value Stream Mapping), as shown in Figure 4.

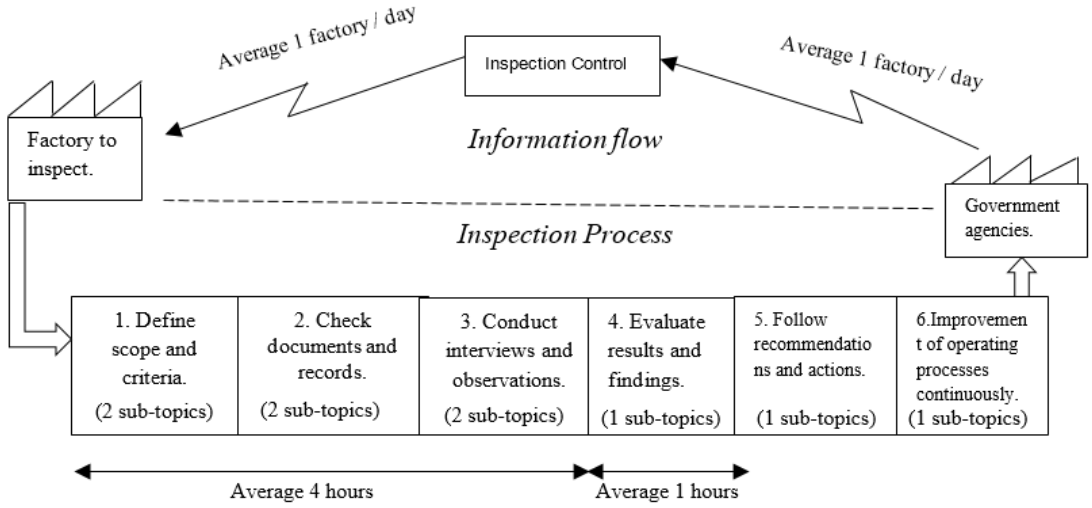

Fig. 4. The value stream mapping after improving Lean.

The satisfaction assessment of program users found that the satisfaction of the users of the factory inspection program for factory certification inspection was high in all four aspects: system analysis and design, accuracy in program usage, information security system, and convenience and ease of use. The average overall satisfaction is 4.67 (the highest level)

Thus, improvements by Lean in the inspection process can be found to be integrative and sustainable (Chand, 2021). The ECRS (Eliminate Combine Rearrange and Simplify) technique, which is a simple process of improving tasks (Kaizen) (Yoo & Shim, 2023), makes the inspection process more efficient and can reduce the process of inspection. The results of the sample satisfaction score were excellent, especially in the analysis and design of the system based on the standards of industrial plant control laws. The accuracy of the program and the data security system are designed by writing a computer language (Python). However, in terms of convenience and ease of use satisfaction scores, it may need to be continuously improved by providing a manual for using the program and conducting training on how to use the program to increase skills in using the program more efficiently and effectively. Regarding the sustainability of improvement, Lean and ECRS changes must be standardized in the management system, such as preparing an operational manual or a standard for continuous improvement. They must also be continuously audited in the Process Safety Management (PSM) system to ensure efficiency and effectiveness in enterprise security management.

5. Conclusion

From the problem of the process safety management system (PSM), the inspection is considered very important and needs improvement to increase efficiency. To solve the problem, this research has improved the inspection process using the concept of lean in factory inspection by reducing waste from the inspection process and applying the idea of "Lean" to the factory inspection process. ECRS and Perfection Management, as well as a new body of knowledge in

using computer program technology to assist in system auditing. PSM, which can meet the requirements of meeting the set objectives, is to improve lean with the inspection of the process safety management system in the plant by reducing the workflow and the inspection period. In addition, the satisfaction assessment results of the program used by the sample of PSM system inspectors were at the highest level of satisfaction.

This research is of interest to researchers and plant inspectors because it shows the potential of the program and the many benefits of implementing the system audit program. In terms of theoretical benefits, it has been found that there has been no research on the application of the Lean philosophy to the audit of Process Safety Management (PSM). Therefore, it is useful to provide more evidence to support research to help promote PSM system audit theory and lean theory, as well as the application of process safety management inspection theory to computer platform systems on the cloud system in the form of big data, which will help to manage safety management data to be up-to-date and complete, such as legal requirements, process chemical data, process chemical data, and standard Operating Procedures, etc.

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References

Amor, R., & Dimyadi, J. (2021). The promise of automated compliance checking. *Developments in the Built Environment, 5*. https://doi.org/10.1016/j.dibe.2020.100039

Amyotte, P. R., & Lupien, C. S. (2017). Elements of process safety management. In *Methods in chemical process safety* (Vol. 1, pp. 87-148). Elsevier. https://doi.org/10.1016/bs.mcps.2017.01.004

Araújo, A., Alves, A. C., & Romero, F. (2021). Barriers to Lean and Pull System implementation: a case study. *IOP Conference Series: Materials Science and Engineering*, *1193*(1), 012048. https://doi.org/10.1088/1757-899X/1193/1/012048

Arey, D., Le, C. H., & Gao, J. (2020). Lean industry 4.0: A digital value stream approach to process improvement. *Procedia Manufacturing*, *54*, 19–24. https://doi.org/10.1016/j.promfg.2021.07.004

Aucasime-Gonzales, P., Tremolada-Cruz, S., Chavez-Soriano, P., Dominguez, F., & Raymundo, C. (2020). Waste Elimination Model Based on Lean Manufacturing and Lean Maintenance to Increase Efficiency in the Manufacturing Industry. *IOP Conference Series: Materials Science and Engineering*, *999*(1). https://doi.org/10.1088/1757-899X/999/1/012013

B. Tepparit and N. Am-Eam, "Design and Development of Self Declarations Program According to the Law of Factory Regulation Control," *Thai Industrial Engineering Network Journal*, Volume 9 (No.1), pp.29–39, 2023. https://ph02.tci-thaijo.org/index.php/ienj/article/view/248297

Badoozadeh, E. S. M. A. I. L., Arefi, M. F., & Babaei-Pouya, A. M. I. N. (2021). Job safety risk assessment in the printing industry using job safety analysis method and offering control recommendations. *Pakistan Journal of Medical and Health Sciences*, *14*(4), 1785-1789.

Badoozadeh, E. S. M. A. I. L., Arefi, M. F., & Babaei-Pouya, A. M. I. N. (2021). Job safety risk assessment in the printing industry using job safety analysis method and offering control recommendations. *Pakistan Journal of Medical and Health Sciences*, *14*(4), 1785-1789.

Bai, M., Qi, M., Shu, C. M., Reniers, G., Khan, F., Chen, C., & Liu, Y. (2023). Why do major chemical accidents still happen in China: Analysis from a process safety management perspective. *Process Safety and Environmental Protection*, *176*, 411–420. https://doi.org/10.1016/j.psep.2023.06.040

Behie, S. W., Halim, S. Z., Efaw, B., O'Connor, T. M., & Quddus, N. (2020). Guidance to improve the effectiveness of process safety management systems in operating facilities. *Journal of Loss Prevention in the Process Industries*, *68*. https://doi.org/10.1016/j.jlp.2020.104257

Chand, M. (2021). Strategic assessment and mitigation of risks in sustainable manufacturing systems. *Sustainable Operations and Computers*, *2*, 206–213. https://doi.org/10.1016/j.susoc.2021.07.004

Chen, S., Jiang, W., & Zhou, C. (2023). Development of permit-to-work management system based on POP model for petrochemical construction safety. *Journal of Intelligent Construction*, *1*(2), 9180012. https://doi.org/10.26599/jic.2023.9180012

de Assis, R. F., de Santa-Eulalia, L. A., Ferreira, W. D. P., Armellini, F., Anholon, R., Rampasso, I. S., & Santos, J. G. C. L. D. (2021). Translating value stream maps into system dynamics models: a practical framework. *The International Journal of Advanced Manufacturing Technology, 114*(11), 3537-3550. https://doi.org/10.1007/s00170-021-07053-y

di Natali, C., Mattila, J., Kolu, A., de Vito, P., Gauttier, S., Morata, M., Garcia, M., & Caldwell, D. (2023). Smart tools for railway inspection and maintenance work, performance and safety improvement. *Transportation Research Procedia*, *72*, 3070–3077. https://doi.org/10.1016/j.trpro.2023.11.856

Dieste, M., Panizzolo, R., Biazzo, S., & Baseggio, A. (n.d.). *Lean Thinking and Workplace Safety: insights from two improvement projects*. https://www.researchgate.net/publication/340128791

Dobrowolski, Z., Sulkowski, L., & Adamisin, P. (2022). Innovative ecosystem: the role of lean management auditing. *Marketing and Management of Innovations*, *13*(3), 9–20. https://doi.org/10.21272/mmi.2022.3-01

Dwiasnati, S., & Hidayat, R. R. (2022). Penerapan Manajemen Risiko Menggunakan COSO: Enterprise Risk Management Framework Integrated Pada PT ALPHANET. *Jurnal Tata Kelola dan Kerangka Kerja Teknologi Informasi, 8*(2), 66–72. https://doi.org/10.34010/jtk3ti.v8i2.7845

Elattar, S., Abed, A. M., & Alrowais, F. (2020). Safety maintains lean sustainability and increases performance through fault control. *Applied Sciences (Switzerland)*, *10*(19). https://doi.org/10.3390/app10196851

Ghasemi Pirbalouti, R., Behnam, B., & Karimi Dehkordi, M. (2023). A risk-based approach to identify safety-critical equipment in process industries. *Results in Engineering*, *20*. https://doi.org/10.1016/j.rineng.2023.101448

Gnoni, M. G., Bragatto, P. A., Milazzo, M. F., & Setola, R. (2020). Integrating IoT technologies for an "intelligent" safety management in the process industry. *Procedia Manufacturing*, *42*, 511–515. https://doi.org/10.1016/j.promfg.2020.02.040

Guo, X. (2023). Analysis of Legal Risks in Psychological Crisis Events among University Students. *Higher Education Studies*, *13*(3), 101. https://doi.org/10.5539/hes.v13n3p101

Halvani, G., & Sahraee, M. (2020). Determine the impact of the implementation of the program checklists resulting from official inspections in identifying hazards in an automotive industry. *Occupational Medicine*. https://doi.org/10.18502/tkj.v11i3.2585

Hazzan, M. J., Rose, M. R., Heller, D. M., & Sanderson, S. (2022). Current challenges in performing PSM audits. *Process Safety Progress, 41*(2), 247-252. https://doi.org/10.1002/prs.12303

Hutchinson, B., Dekker, S., & Rae, A. (2024). How audits fail according to accident investigations: A counterfactual logic analysis. *Process Safety Progress*. https://doi.org/10.1002/prs.12579

Kanoksirirujisaya, N. (2022). Reducing waste in frozen crab stick product inspection process by applying ECRS technique. *International Journal of Health Sciences*, 1506–1523. https://doi.org/10.53730/ijhs.v6ns4.6236

Kešeľová, M., Blištanová, M., Hanák, P., & Brůnová, B. (2021). Safety Management System in Aviation: Comparative Analysis of Safety Management System Approaches in V4

Countries. *Management Systems in Production Engineering*, *29*(3), 208–214. https://doi.org/10.2478/mspe-2021-0026

Kumar, A. Y. (2024). The New Three-Dimensional Safety Approach for the Implementation of Process Safety Management (PSM) and Improving Safety Aspects for the Pharmaceutical Industry in India – An Overview. *Indonesian Journal of Innovation and Applied Sciences (IJIAS)*, *4*(1), 44–54. https://doi.org/10.47540/ijias.v4i1.1269

Leksic, I., Stefanic, N., & Veza, I. (2020). The impact of using different lean manufacturing tools on waste reduction. *Advances in Production Engineering And Management*, *15*(1), 81–92. https://doi.org/10.14743/APEM2020.1.351

Manservisi, F., Banzi, M., Tonelli, T., Veronesi, P., Ricci, S., Distante, D., Faralli, S., & Bortone, G. (2023). Environmental complaint insights through text mining based on the driver, pressure, state, impact, and response (DPSIR) framework: Evidence from an Italian environmental agency. *Regional Sustainability*, *4*(3), 261–281. https://doi.org/10.1016/j.regsus.2023.08.002

Markowski, A. S., Krasławski, A., Vairo, T., & Fabiano, B. (2021). Process safety management quality in industrial corporation for sustainable development. *Sustainability (Switzerland)*, *13*(16). https://doi.org/10.3390/su13169001

Marques, J. P., Sá, J. C., Silva, F. J. G., Pereira, T., Ferreira, L. P., & Santos, G. (2021). Safety efficiency value stream mapping (SEVSM) - A new tool to support the implementation of Lean Safety. *IOP Conference Series: Materials Science and Engineering*, *1193*(1), 012124. https://doi.org/10.1088/1757-899X/1193/1/012124

Moore, D. A., Hazzan, M. J., Heller, D. M., & Rose, M. R. (2015). *Enterprise PSM Development, Implementation, and Auditing*. https://doi.org/10.1002/prot.11690

Noman, M., Mujahid, N., & Fatima, A. (2021). The Assessment of Occupational Injuries of Workers in Pakistan. *Safety and Health at Work*, *12*(4), 452–461. https://doi.org/10.1016/j.shaw.2021.06.001

Nwankwo, C. D., Theophilus, S. C., & Arewa, A. O. (2020). A comparative analysis of process safety management (PSM) systems in the process industry. *Journal of Loss Prevention in the Process Industries*, *66*. https://doi.org/10.1016/j.jlp.2020.104171

Pertiwi, A. F. O., & Astuti, R. D. (2020). Increased line efficiency by improved work methods with the ECRS concept in a washing machine production: a case study. *Jurnal Sistem Dan Manajemen Industri*, *4*(1), 13–29. https://doi.org/10.30656/jsmi.v4i1.2184

Rodrigues, F., Antunes, F. and Matos, R. (2021), "Safety plugins for risks prevention through design resourcing BIM", Construction Innovation, Vol. 21 No. 2, pp. 244-258. https://doi.org/10.1108/CI-12-2019-0147

Rudakov, M., Gridina, E., & Kretschmann, J. (2021). Risk-based thinking as a basis for efficient occupational safety management in the mining industry. *Sustainability (Switzerland)*, *13*(2), 1–14. https://doi.org/10.3390/su13020470

Saleem, F., & Malik, M. I. (2022). Safety Management and Safety Performance Nexus: Role of Safety Consciousness, Safety Climate, and Responsible Leadership. *International Journal of Environmental Research and Public Health*, *19*(20). https://doi.org/10.3390/ijerph192013686

Siuta, D., Kukfisz, B., Kuczyńska, A., & Mitkowski, P. T. (2022). Methodology for the Determination of a Process Safety Culture Index and Safety Culture Maturity Level in Industries. *International Journal of Environmental Research and Public Health*, *19*(5). https://doi.org/10.3390/ijerph19052668

Slezak, M., Behie, S., & Pasman, H. (2022). Digital process safety management. In *Methods in Chemical Process Safety* (Vol. 6, pp. 139-177). Elsevier. https://doi.org/10.1016/bs.mcps.2022.05.008.

Sundaram, S., & Zeid, A. (2023). Artificial Intelligence-Based Smart Quality Inspection for Manufacturing. *Micromachines*, *14*(3). https://doi.org/10.3390/mi14030570

Tang, K. H. D. (2021). A Case Study of Asset Integrity and Process Safety Management of Major Oil and Gas Companies in Malaysia. *Journal of Engineering Research and Reports*, 6–19. https://doi.org/10.9734/jerr/2021/v20i217260

Tortorella, G., Cómbita-Niño, J., Monsalvo-Buelvas, J., Vidal-Pacheco, L., & Herrera-Fontalvo, Z. (2020). Design of a methodology to incorporate lean manufacturing tools in risk management, to reduce work accidents at service companies. *Procedia Computer Science*, *177*, 276–283. https://doi.org/10.1016/j.procs.2020.10.038

Virtanen, W. (2022). *IMPLEMENTING LEAN ON QUALITY AND INSPECTION PROCESS-Case Company A*.

Wang, Y., Wei, H., Wang, Y., Peng, C., & Dai, J. (2021). Chinese industrial water pollution and the prevention trends: An assessment based on environmental complaint reporting system (ECRS). *Alexandria Engineering Journal*, *60*(6), 5803–5812. https://doi.org/10.1016/j.aej.2021.04.015

Yeshitila, D., Kitaw, D. and Jilcha, K. (2021) Applying Lean Thinking to Improve Operational Safety in Oil and Gas Industry. Open *Journal of Safety Science and Technology*, 11, 120-141. https://doi: 10.4236/ojsst.2021.113009.

Yoo, B. T., & Shim, W. S. (2023). Evaluating the Efficiency of the Process Safety Management System through Analysis of Major Industrial Accidents in South Korea. *Processes*, *11*(7). https://doi.org/10.3390/pr11072022

Zhang, J., Ren, H., Ren, H., Chai, Y., Liu, Z., & Liang, X. (2023). Comprehensive Review of Safety Studies in Process Industrial Systems: Concepts, Progress, and Main Research Topics. In *Processes* (Vol. 11, Issue 8). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/pr11082454

Zielinski Nguyen Ajslev, J., & Elisabeth Ejstrup Nimb, I. (2022). Virtual design and construction for occupational safety and health purposes – A review on current gaps and directions for research and practice. In *Safety Science* (Vol. 155). Elsevier B.V. https://doi.org/10.1016/j.ssci.2022.105876