

EVALUATION OF THE CAUSES OF PERTALITE TANK FIRES IN PT X USING *THE SWISS CHEESE METHOD*

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Abstract

Work accidents are a risk that can occur in various industrial sectors, including the oil and gas sector which has a high potential for danger. This article discusses the case of a pertalite tank fire at PT X, which became one of the significant incidents in the oil refinery industry in Indonesia. This study aims to analyze the causes of the incident, the impact caused, and preventive efforts that can be made to minimize similar risks in the future. Data was obtained through document reviews, incident investigation reports, and literature related to industrial fires. The results of the analysis showed that this fire was caused by a combination of technical factors, such as the failure of the tank safety system, and human factors, including a lack of compliance with safety procedures. The impacts caused include significant material losses, operational disruptions, and environmental impacts and the health of the surrounding community. To prevent similar incidents, the recommendations included increased periodic inspections, improvement of standard operating procedures (SOPs), occupational safety training for employees, and the application of more advanced fire detection technology. This study is expected to be an evaluation material for similar industries to improve risk management and occupational safety systems.

Keywords: Tank fire, occupational safety, oil and gas industry.

Introduction

Petroleum as a raw material for the manufacture of fuel oil (BBM), gasoline and many other chemical products is one of the most important energy sources in Indonesia (Erdiwansyah et al., 2021). The Ministry of Energy and Mineral Resources (EMR) noted that in 2014, the most energy consumption in Indonesia was still dominated by oil, which was 41.0% of the total national energy consumption (Wong, Ng, Chong, Lam, & Chong, 2019). Oil consumption, especially fuel, continues to increase as a result of economic growth and population growth, while domestic crude oil production continues to decline and stagnant refinery capacity causes crude oil and fuel imports to increase (Melati, 2018).

Fires in fuel storage facilities, such as Peralite tanks, are a serious threat that can result in significant environmental, economic, and social impacts. In Indonesia, the use of Peralite continues to increase along with the growth of industry and transportation, fire incidents are an urgent issue to be addressed (Ashary, Kurniawan, & Widjasena, 2017). Data shows that fires in storage facilities are often caused by a combination of human, technical, and environmental factors. Therefore, a comprehensive understanding of the causes and mechanisms of fires is essential to improve operational safety in the industry (Utama, Suparta, & Dulhadi, 2022).

Previous studies have identified the factors that cause fires in the fuel storage industry. For example, research by (Putra, 2024) emphasizes that human error and lack of adequate training often contribute to fire incidents. In addition, (Ismail, 2024) showed that early detection systems and inadequate maintenance can exacerbate fire risk. Although many studies have been conducted, there is still a lack of an integrated analytical approach to thoroughly evaluate fire risk. Notably, *the Swiss Cheese* method, known as a risk analysis tool, has not been widely applied in the specific context of Peralite tank fires.

This study uses an innovative approach by applying *the Swiss Cheese* method to analyze the causes of Peralite tank fires in PT X. Using this model, this study not only focuses on identifying individual risk factors but also explores the interactions between the layers of defense that can lead to overall system failure. This approach is expected to provide a new perspective in fire risk management (Wardhani, 2018).



Figure 1
Peralite Tank Fire at PT X

On November 13, 2021, a fire and explosion occurred in the 36T-102 tank belonging to PT X which resulted in severe damage but no casualties. PT X is one of the seven largest processing units in Indonesia with a production capacity of 348 thousand barrels per day. This refinery supplies 34% of national fuel needs and 60% in Java, as well as producing asphalt for infrastructure and *lube base oil* for lubricants. (Directorate of Oil and Gas Engineering and Environment, 2022)

Based on the literature review, the hypothesis of this study is that the application of *the Swiss Cheese* method will identify weak layers of defense and complex interactions between various risk factors that contribute to Peralite tank fires. Thus, this study aims to answer the critical question: "What are the unidentified risk factors that can cause fires in PT X?"

The purpose of this study is to critically evaluate the causes of Peralite tank fires using *the Swiss Cheese* method and provide strategic recommendations for risk mitigation at PT X. With the results of this study, it is expected to make a significant contribution to improving operational safety as well as the development of fire prevention protocols in the fuel storage industry. This research also aims to enrich the literature related to risk management with a more holistic and integrated approach.

Research Methods

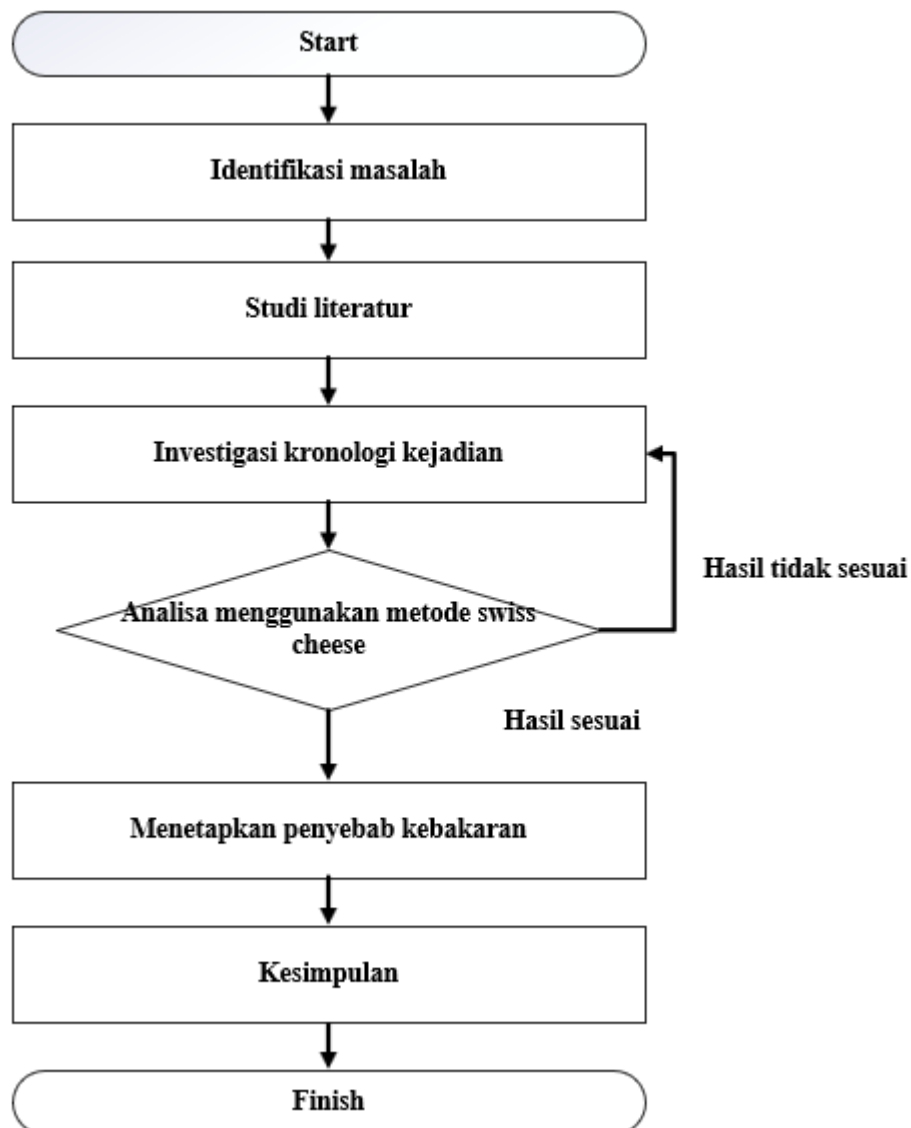


Figure 2

Flowchart of Peralite Tank Fire Investigation

From these problems, *the Swiss cheese* method is used. In this case, *the Swiss cheese* method is a model that describes how an accident occurs. Holes in cheese represent weaknesses or failures in the system. Then, each slice represents a single layer of protection. When there are several holes in different layers in parallel, then accidents occur. By identifying and closing holes in each layer of protection, it can prevent similar fires in the future (Fahd, M., Puspitasari, N. B., & Rumita, 2019).

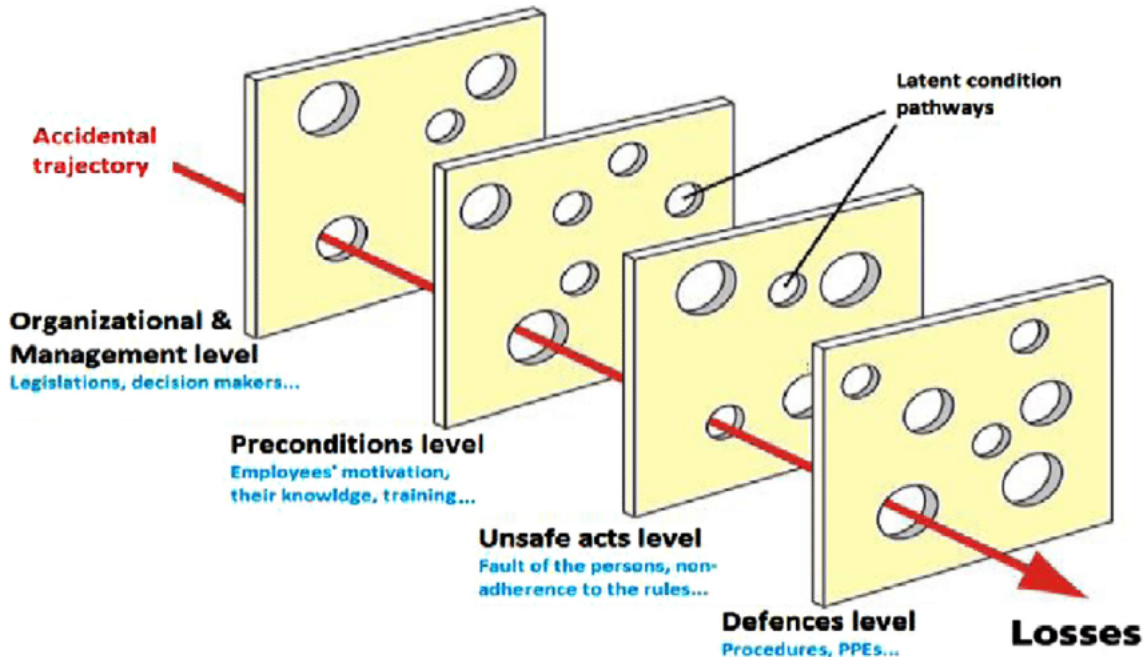


Figure 3 Schematic of Swiss Cheese Theory

In this theory, (Larouzee & Le Coze, 2020) divide the causes of negligence or errors in the industry into 4 levels:

1. *Unsafe acts*
2. *Preconditions for unsafe acts*
3. *Unsafe supervision*
4. *Organizational influences*

In the Swiss Cheese Model, the various types of errors that exist in the industry represent holes in a cheese. If all four of them both have holes, then accidents are inevitable. The research methods used in problem solving include analysis methods. In this case, the image caption is placed as part of the image title (*figure caption*) which is not part of the image. The methods used in completing the research are described in this section (Angélil, Richthofen, Kim, & Roth, 2019).

Results and Discussion

Broadly speaking, there are 5 main stages of industrial activities or oil and gas business in Indonesia, starting from the exploration, production, then processing, transportation, and finally marketing. The 5 main stages are divided into two activities, namely upstream activities and of course downstream activities). Downstream oil and gas

activities include processing, transportation and marketing stages. Processing is the activity of purifying, obtaining parts, improving quality and increasing the added value of petroleum or natural gas, but not by field processing or commonly called production exploration. Crude oil processing is carried out at petroleum refineries as an equipment system to process crude oil (petroleum) into various fuel or non-fuel products.

According to the Decree of the Minister of Manpower of the Republic of Indonesia No. 463/MEN/1993, occupational safety and health is a protection effort shown so that workers and other people in the workplace or company are always in a safe and healthy state, and so that every source of production can be used safely and efficiently. The outline of the purpose of this research is to analyze the tragedy of the pertalite 36 T-102 tank fire at PT. X by using the Swiss cheese theory method with great hopes can make an evaluation, which is still a stage of the oil and gas processing process in the downstream (*upstream*).

According to the opinion of (Sofwatulifida, 2020), the factors that cause work accidents are divided into various aspects that have the potential to cause accidents. The causes of work accidents in the oil and gas sector can be categorized into five main factors, namely human factors, such as non-compliance with work procedures, lack of worker competence, and poor occupational safety management systems; tool or machine factors, such as the condition of the tool that is old and vulnerable, lack of maintenance, welding defects, and the risk of noise, vibration, and temperature extremes; material factors, such as chemical hazards such as poisoning, fire, environmental pollution, and the risk of burns from LNG; process or work method factors, such as high-risk work methods and the absence of adequate operating standards; and environmental or natural factors, such as the influence of extreme natural conditions and noise and vibration in the work environment that exceed the threshold.

The following can be seen the chronology of the incident of the 36T-102 tank fire in table 1 below.

Table 1 Chronology of events

Day, Date	Time (WIB)	Event
Thursday, 11 November 2021	22.00	Filling of the 36T-102 tank with pertalite products with an initial level of 2,406 mm.
Saturday, 13 November 2021	14.40	Charging has been completed with a final level of 14,076 mm and stopped.
	14.50	Pertalite products are <i>blended</i> with naphtha products from tank 36T-105.
	18.30	It began to rain heavily accompanied by lightning.
	18.45	The fireman <i>patrol team</i> patrols the tank area according to procedures when it rains heavily.

19.00	Blending activities were stopped because the level of 36T-102 had reached 15,900 mm (according to order), and <i>the mixer</i> was turned off due to weather conditions at that time that were rainy accompanied by lightning.
19.10	From the CCTV located on the <i>Rooftop</i> , the <i>Maintenance Office</i> (MO) office saw a flash of lightning striking in the area of tank 36 and followed by a fire in tank 36T-102
19.11	<ul style="list-style-type: none"> ● The fireman patrol team received information from the fire station who saw from CCTV that there was a fire and went straight to the location of tank 36T-102. ● Firefighters made extinguishing efforts by using extinguishing foam on the 36T-102 tank and bundwall. ● Firefighters cooled by using water jets on tanks 36T-101 and 36T-103.
19.22	Emergency declaration by GMn RU IV Cilacap.
19-25-23.00	<ul style="list-style-type: none"> ● Preparation for heating <i>High Capacity Fire Extinguisher</i> (HCFE). ● The product was transferred from tank 36T-102 to tank T 71-21 which is located in area 70. ● The extinguishing uses HCFE in the northern part of the tank to assist in the extinguishing process while the time <i>fire</i> focuses on the southern part of the tank. ● A new line was added to the T-71-2 tank to speed up the transfer of products from the 36T-102 tank.
Sunday, 14 November 2021 07.45-23.00	<ul style="list-style-type: none"> ● The fire was successfully extinguished with the cooling process still ongoing. ● The safety condition statement was issued by the General Manager of

RU IV Cilacap and the safety condition siren sounded.

- Stopped cooling the tank and pumping the product because the fluid inside the 36T-102 tank had reached its lowest level.

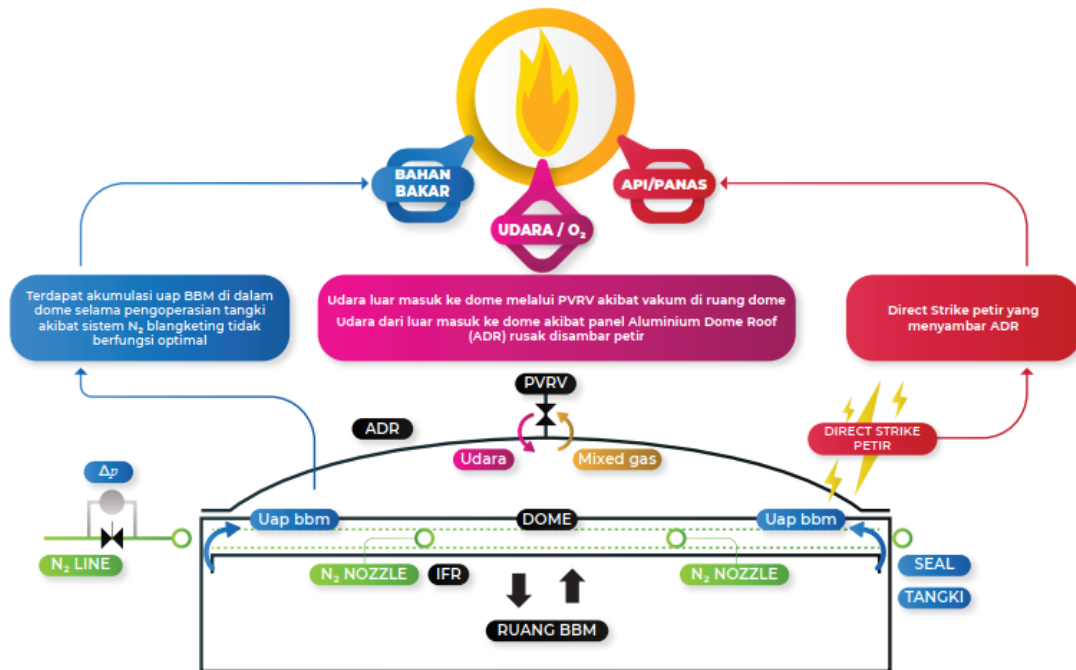


Figure 4
Illustration of the Cause of Fire

Based on the illustration above, it can be seen that the 36T-102 tank fire can occur because it has met the requirements for the formation of a fire from the triangle of fire, namely fuel, air, and heat sources. Based on the data that has been obtained, it can be seen that the source of fuel is the accumulation of fuel vapor in the dome. This is due to the N₂ system *blanketing* The tank does not function optimally. The air source comes from the outside air that enters the dome through the PVRV due to the vacuum in the dome chamber. Air from the outside enters the dome due to the Aluminum panel *Dome Roof* (ADR) was damaged by lightning. The heat source in this triangle of fire comes from *Direct Strike* Lightning strikes *Aluminum Dome Roof* (ADR).

Based on the data that has been obtained, the researcher analyzed and evaluated work accidents using *the Swiss cheese theory* technique. *Swiss cheese theory* is a model or method used to analyze risks and risk management in a system, especially in the context of occupational safety and health. This model is often used to understand how accidents or system failures can occur, although there are many layers of protection. The following are the results of the analysis of work accidents using *the Swiss cheese theory technique*.

Table 2 Analysis of work accidents using *the Swiss cheese theory technique*

Layer	Hole	Analysis Results
Organizational Influences	Standards Procedures	andThere are negligence in the application of standards and procedures related to maintenance of lightning protection systems, gas detection, and routine inspections of tanks.
	Safety Culture	A weak occupational safety culture can lead to a lack of attention to external hazards such as lightning strikes.
	Maintenance	When performing equipment maintenance, maintenance is carried out not strictly and ignores existing standard procedures.
Unsafe Supervision	Inspection	At the time of routine inspections of tanks, lightning protection systems and gas detectors were not carried out thoroughly and there was no supervision.
	Reporting	There are reports that are not in accordance with the conditions of the field, so that the supervisor is not aware of the existence of unsafe equipment.
Precondition for Unsafe Act Safety Equipment		The lack of safety equipment in the area 36 tank is the absence of lightning rods and gas detectors. There is a leak in the blanketing system.
	Environmental conditions	Extreme weather conditions such as rain and lightning cause an increase in the risk of accidents.

Unsafe Act	Maintenance	At the time of maintenance, it is not carried out in accordance with the existing SOPs.
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Based on the results of the accident analysis with the *Swiss cheese theory*, The 36T-102 tank fire was caused by a series of interrelated system failures. The main factor that caused this to happen was a lightning strike that directly hit the tank and this incident was exacerbated by a number of weaknesses in the safety system, such as the absence of lightning rods, the absence of gas detectors, and the presence of a leak in the blanketing system that was unknown. Referring to the results of the analysis that the researcher has done, there are recommendations that need to be implemented by the company so that incidents like this do not recur. The recommendation that the researcher can provide is that the company can improve the lightning protection system in the form of installing external lightning rods that are in accordance with standards and carrying out routine maintenance, the company can improve the fire detection system by installing gas detectors. In addition, companies must improve the existing blanketing system and ensure that there is an appropriate pressure indicator on the system.

Conclusion

Based on the analysis of the 36T-102 tank fire at the PT X Refinery using the *Swiss Cheese Theory* method, it can be concluded that the incident occurred due to a failure involving various factors. The main factors include negligence in the implementation of standard procedures related to the maintenance of lightning protection systems, gas detection, and routine inspections of tanks. In addition, a suboptimal work safety culture also worsens risk management in the work environment. Equipment conditions such as damage to the blanketing system and ineffective lightning rods are also major factors in forming a fire triangle (fuel, air, and heat source) that causes fires.

To prevent similar incidents, it is necessary to improve safety standards, thorough inspections, regular maintenance in accordance with SOPs, and strengthen the culture of occupational safety. This research makes an important contribution in evaluating accident risk factors in the downstream oil and gas sector, which can be a reference for improving safety systems in the future.

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First publication right:

Syntax Literate: Indonesian Scientific Journal

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