



(CASE REPORT)



Exploding danger: A forensic analysis of the paint thinner explosion incident

Sandeep K Vaishnav, Pankaj Tamrakar *, Dinesh K Sahu and Rajesh Mishra

State Forensic Science Laboratory, Police line Campus, Tikrapara, Raipur, Chhattisgarh. India.

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Abstract

This case study examines a paint thinner explosion incident that occurred in a residential house, resulting in the loss of life, injuries and property damage. The study investigates the explosive characteristics of paint thinner, storage conditions, ignition sources, human factors, and the findings of a forensic investigation. The incident involved an individual attempting to open a plastic container of paint thinner, which exploded upon opening, causing the individual's incapacitation and subsequent death. Three family members standing nearby suffered serious injuries. The forensic investigation revealed accumulation of flammable vapors due to high temperatures and poor ventilation, potential ignition from nearby bamboo stick burning, inadequate safety measures, and human errors as contributing factors. The study emphasizes the importance of proper storage, handling, and training in dealing with flammable substances, as well as the need for effective safety measures and adherence to regulations to prevent such incidents in the future.

Keywords: Paint thinner; Forensic investigation; Vapor pressure; Volatile Organic Compounds

1. Introduction

The objective of this case study report is to analyse a tragic incident that occurred in 19 April 17, leading to the unfortunate loss of one life and causing injuries to three individuals. The incident pertains to the unsealing of a container of paint thinner, a commonly utilised solvent in a wide range of industrial and domestic applications. Paint thinners commonly consist of volatile substances that possess the potential for explosiveness if mishandled or exposed to specific conditions [1].

In this report, we aim to delve into the circumstances surrounding the paint thinner explosion, analyzing its explosive properties, the factors that led to the incident, and the subsequent consequences [2]. By understanding the underlying causes and lessons learned from this case, we hope to promote safety awareness and prevent similar incidents from happening in the future.

Throughout the report, we discussed the characteristics of paint thinners that contribute to their explosive nature and explore the various safety precautions and guidelines necessary for their handling. By comprehensively examining this case, we aim to shed light on the potential dangers posed by volatile substances such as paint thinners and emphasize the importance of maintaining a vigilant approach when handling such materials. Ultimately, this case study serves as a reminder of the critical role that safety measures play in ensuring the well-being of individuals and preventing tragic incidents in the workplace and beyond [3].

* Corresponding author: Pankaj Tamrakar

1.1. Background and Context

Paint thinners, also known as paint solvents, are commonly used in a variety of applications, including painting, cleaning, and surface preparation. These solvents play a crucial role in industries such as automotive, construction, manufacturing, and painting trades. They facilitate the efficient application of coatings, aid in the cleanup of equipment and tools, and contribute to the overall quality and finish of painted surfaces. These solvents are designed to dissolve or dilute paints, varnishes, and other coatings, making them easier to apply or remove. Paint thinners typically consist of a mixture of organic solvents, such as mineral spirit, turpentine, toluene, xylene, and acetone, among others [1-6].

On 19.04.2017 in Raipur, a tragic incident unfolded involving the explosion of a container of paint thinner. The incident occurred in a residential house, where an individual was attempting to open a plastic container of paint thinner. At the time of the incident, three family members were standing in close proximity to the person opening the container. As the plastic container was being opened, a sudden and powerful explosion occurred, accompanied by a loud sound. The force of the explosion caused severe injuries to the individual who was opening the container, ultimately resulting in their untimely death. The other family members who were nearby also suffered serious injuries due to the impact of the explosion. This incident serves as a poignant reminder of the potential risks associated with the mishandling or improper storage of paint thinners.

The incident underscores the critical importance of safety practices when working with volatile substances such as paint thinners. Failure to understand and address the explosive characteristics of these solvents can lead to devastating consequences. It highlights the need for robust safety protocols, training, and awareness campaigns to mitigate risks and ensure the well-being of individuals in various settings where paint thinners are utilized.

2. Explosive Characteristics of Paint Thinner

Let us understand the properties and traits that make paint thinners highly flammable and potentially explosive. Understanding these characteristics is essential for explaining the explosion incident. We have discussed key aspects such as the flash point, flammability limits, and vapor pressure of paint thinners. By gaining insights into these explosive characteristics, the potential cause of the incident can be identified.

2.1. Chemical Composition

Paint thinners typically consist of a mixture of volatile organic compounds (VOCs), including substances such as toluene, xylene, acetone, and others. These organic solvents possess properties that make them highly flammable and potentially explosive.

The flash point of a substance refers to the lowest temperature at which its vapors can ignite when exposed to an open flame or spark. Paint thinners often have low flash points, such as below 25 °C (77 °F). This characteristic makes them highly volatile and prone to combustion. It is essential to handle paint thinners with caution, ensuring that potential ignition sources are kept away from their vapors [3-4].

2.2. Explosive Limits: Lower Explosive Limit (LEL) and Upper Explosive Limit (UEL)

Paint thinners, like other flammable substances, have specific flammability limits known as the Lower Explosive Limit (LEL) and Upper Explosive Limit (UEL). The LEL is the minimum concentration of the substance's vapors in the air required to form an explosive mixture, while the UEL represents the maximum concentration above which the mixture becomes too rich to ignite. Thinner has LEL 1.70% and UEL 7.0%, this signifies that very low amount of its vapor can lead to significant explosion [3-4].

2.3. Vapor Pressure

Paint thinners have high vapor pressures, which mean they evaporate quickly at room temperature. The rapid evaporation leads to the release of a significant amount of flammable vapors into the surrounding environment. In poorly ventilated areas or confined spaces, the accumulation of these vapors can create an explosive atmosphere. Monitoring and controlling the vapor pressure of paint thinners through proper ventilation are essential to minimize the risk of explosion [5-6].

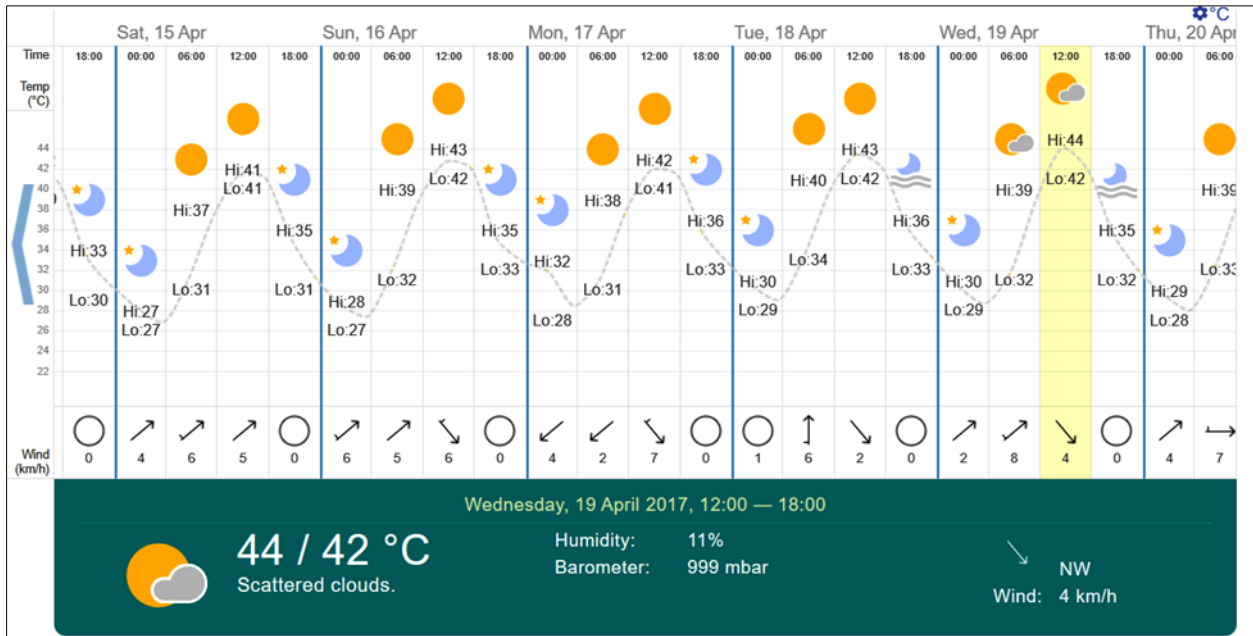


Figure 1 Weather Summary of the day of incident and past days [7].

3. Factors Contributing to the Incident

3.1. Temperature Consideration

The summer days with temperatures reaching around 40 °C (104 °F) or higher might responsible for the increase in vapor pressure inside the container. The storage of the container in such place for long time might increase the vapor pressure of the substances, potentially leading to a higher risk of ignition. (Figure 1)

3.2. Storage

The Paint thinner container was stored in the store room which has roof of tin shed. The potential heat transfer from the tin material in high summer temperatures might exacerbate the volatility of the stored paint thinners. This contributes in fulfilling the requirement of explosion triangle and pentagon. (Figure 2, Figure 3a)

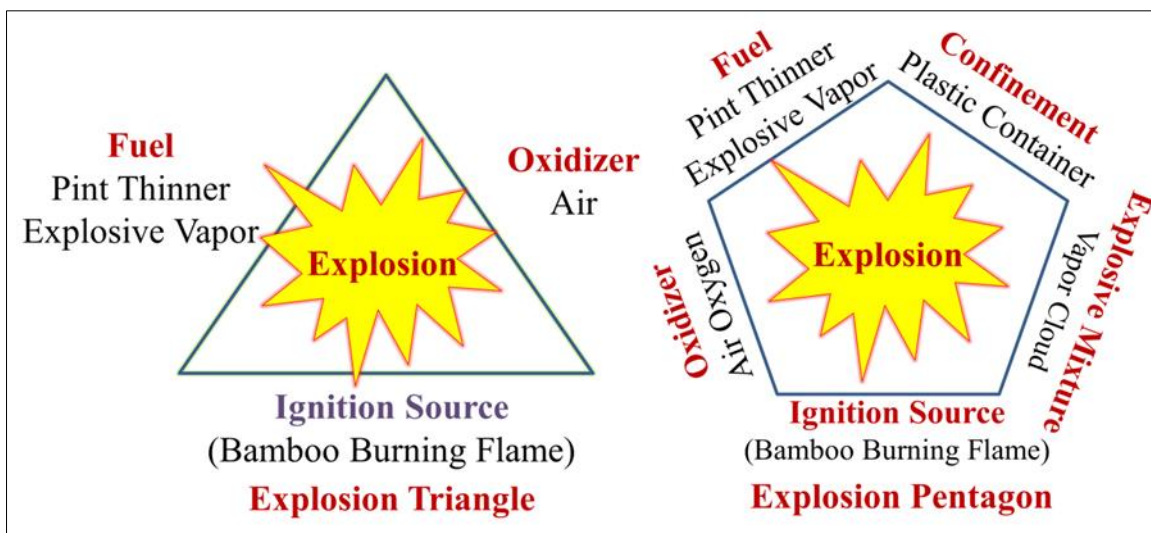


Figure 2 Explosion Triangle and Explosion Pentagon

3.3. Ignition sources and potential triggers

In any environment where flammable substances like paint thinners are stored, it is crucial to recognize and manage potential ignition sources to prevent accidents and explosions. The presence of burned bamboo sticks near the explosion site in this case study raises concerns about their possible contribution as ignition sources. These bamboo sticks, when combined with fuel and oxygen, could have formed the elements of the explosion triangle, which represents the three necessary components for an explosion to occur. (Figure 2) Furthermore, the concept of the explosive pentagon, which adds chemical reaction and confinement as additional elements, highlights the importance of understanding the complete set of conditions that can lead to an explosion. (Figure 2) Thus, considering the burned bamboo sticks within the context of the explosion triangle and explosive pentagon becomes essential in assessing their potential role as an ignition source in this incident.

3.4. Lack of Knowledge and Poor Handling Practices

Insufficient knowledge regarding the properties, handling, and storage of flammable substances like paint thinners were one of the reasons behind this accident. Furthermore, Improper handling of container while opening the container probably near the burning bamboo sticks revealed the Inadequate understanding of the risks associated with handling flammable substances. (Figure 3)

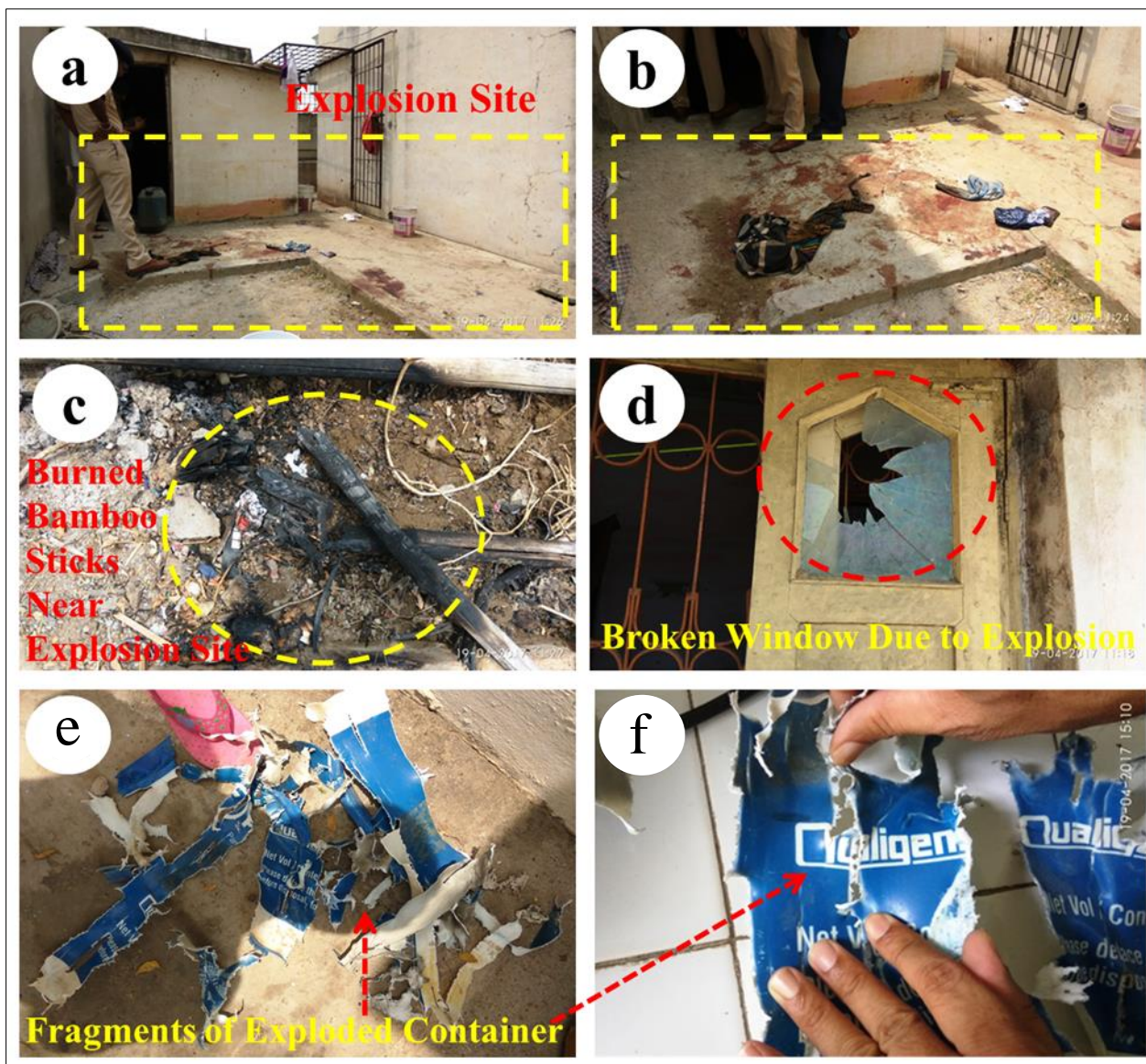


Figure 3 (a) Explosion site (b) Explosion site with blood, blood shed cloths and pieces of flesh (c) Burned bamboo sticks near explosion site (d) Broken window due to explosion effect (e-f) Fragment of exploded container recovered from explosion site

3.5. Accumulation of Flammable Vapors

The investigation determined that the paint thinner container had been stored for an extended period in a hot and poorly ventilated environment. The high temperatures and lack of adequate ventilation resulted in the accumulation of flammable vapors within the container. The combination of volatile solvents and elevated temperatures significantly increased the vapor pressure, creating an explosive atmosphere within the container. (Figure 1, 2 and 3)

3.6. Ignition Source

Based on the forensic investigation, one of the potential ignition sources in the paint thinner explosion incident could be attributed to burning bamboo sticks near the explosion site. While the exact cause of ignition cannot be definitively determined without conclusive evidence, the presence of burning bamboo sticks in close proximity to the area raises suspicions of their involvement.

The burn marks and residue found on the bamboo sticks suggest that they were being used for some purpose. The high temperature generated by the burning bamboo sticks could have provided the necessary heat energy to ignite the flammable vapors released from the paint thinner container. (Figure 3 c)

3.7. Inadequate Safety Measures

The forensic investigation uncovered a lack of proper safety measures in the storage and handling of the paint thinner. The storage location, a store room situated outside the main house, did not meet the required safety standards for storing flammable materials. The absence of measures to prevent the accumulation of flammable vapors and the lack of fire suppression systems further contributed to the hazardous conditions.

3.8. Human Error

The investigation highlighted potential human errors that played a role in the incident. The individual attempting to open the container might not have been adequately trained in the safe handling and opening procedures of flammable substances. This lack of knowledge, combined with the opening of paint thinner container near burning bamboo sticks, demonstrated a lapse in judgment and adherence to safety protocols. Based on these findings, it is evident that a combination of factors contributed to the paint thinner explosion. The hot summer, storage location of the container, the accumulation of flammable vapors, the potential ignition source, inadequate safety measures, and human errors collectively created a hazardous situation that ultimately led to the explosion. Figure 4 demonstrated a schematic representation of the hypothesis based on above findings. The findings of the forensic investigation emphasize the importance of proper storage, handling, and maintenance of flammable substances. It underscores the need for robust safety protocols, regular inspections, and comprehensive training programs to mitigate the risks associated with such materials.

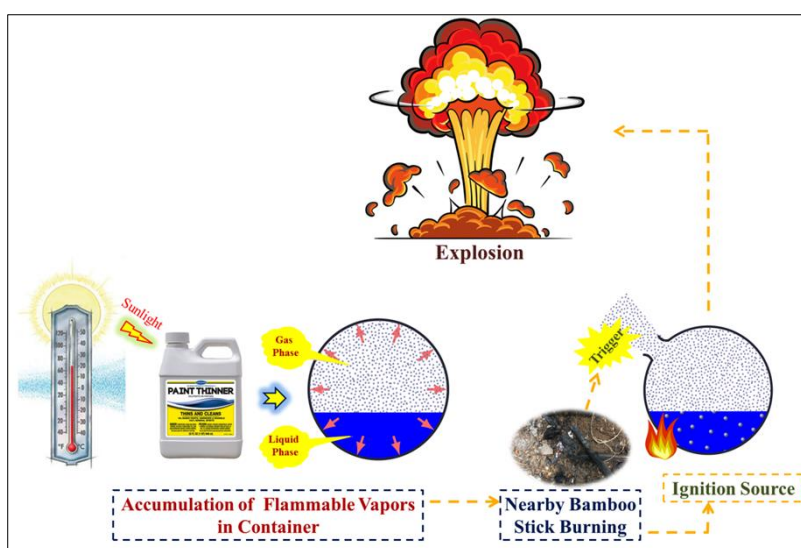


Figure 4 Schematic Representation of the Probable cause of explosion Incident

4. Conclusion

The paint thinner explosion incident discussed in this case study serves as a stark reminder of the hazards associated with flammable substances and the critical importance of adhering to proper storage, handling, and safety protocols. The investigation and analysis of this incident have shed light on several key factors that contributed to the catastrophic outcome.

The explosive characteristics of paint thinner, such as its low flash point and high vapor pressure, make it highly susceptible to ignition and subsequent explosion when exposed to an ignition source. The accumulation of flammable vapors in a hot and poorly ventilated storage area, created an ideal environment for a potential disaster. Human factors and errors further exacerbated the risks. Inadequate training and awareness regarding the handling of flammable substances, coupled with the opening of container near burning bamboo sticks acted as triggers for the ignition source.

The consequences of the incident were devastating, resulting in the loss of life, serious injuries, significant property damage, environmental impact, and psychological trauma for those directly and indirectly affected. The incident serves as a call to action for improved safety regulations, robust training programs, and stringent adherence to storage and handling guidelines to prevent similar incidents from occurring in the future.

To mitigate the risks associated with flammable substances, it is imperative that individuals and organizations prioritize safety at every stage. This includes implementing rigorous safety protocols, ensuring proper storage conditions, providing comprehensive training to personnel, promoting awareness of potential hazards, and regularly inspecting and maintaining containers and storage facilities. By applying these preventive measures, individuals and organizations can mitigate the risks and protect lives, property, and the environment from the catastrophic consequences of incidents like the paint thinner explosion. Safety should always be paramount when dealing with flammable substances, and a culture of safety consciousness must be fostered to prevent future tragedies.

This case study highlights the need for continuous improvement in safety practices and serves as a valuable lesson for individuals, households, and industries involved in the handling, storage, and use of flammable materials. By learning from past incidents and implementing effective safety measures, we can strive towards a safer and more secure environment for all.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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