Lessons Learnt Case Report

Flash Fire in Confined Space

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Case Study:
Flash Fire in Confined Space

Introduction

1 On the incident day in September 2007, a team of 6 workers were doing roller painting in a confined space when a flash fire occurred. All workers managed to climb out of the confined space. However, 4 workers sustained burns while 2 other workers were unhurt. Seven days later, one of the 4 victims succumbed to his injuries due to complication of inhalational injury and extensive burns. This Lessons Learnt Case Report analyses the cause of the incident using the 5M (Machine, Man, Management, Medium and Mission) model (see Annex). Recommendations to prevent such incidents from happening are also included.

Summary of Events

2 Ten days before the incident, Employer applied for a confined space permit-to-work (PTW) for roller painting and cleaning work in the pontoon tank. The PTW was for the painting work to be carried out within the next 2 weeks.

3 The pontoon tank was gas checked for oxygen, carbon monoxide and hydrogen sulphide levels by a safety promoter. It was certified to be safe for entry.

4 A week later, spray painting work was carried out for 2 days in the same pontoon tank, but applied under a different PTW. Ventilation was provided during the spray painting work and intrinsically safe hand-held torch lights were used as the only source of lighting.

5 This was immediately followed by 2 days of roller painting undertaken by a team of 6 workers, including Worker and Painter.

6 On the following morning (the day of the incident), the same safety promoter conducted a gas check and observed no abnormalities. No Lower Explosive Limit (LEL) was detected. The PTW was endorsed for work to be continued.

7 The same team of 6 workers then carried out vacuuming and tank cleaning work using thinner (a flammable solvent).

8 At around noon, the safety promoter conducted a 2nd gas check and no LEL was detected. He thus endorsed on the PTW for work to be continued.

9 Few hours later, a joint inspection was conducted by Worker together with representatives from the rig’s owner, occupier and paint manufacturer to assess the quality of the paint work. The inspection ended in late afternoon and Worker was instructed to perform touch up painting at some areas in the pontoon tank.
Worker then instructed his team members (including Painter) to carry out preparation works in the pontoon tank to facilitate the touch up painting using roller brushes. After the safety promoter had conducted and endorsed the 3rd gas check, the workers brought in drums of paint and hardener into the tank.

One of the workers mixed the paint and hardener in the pontoon tank for 5 minutes. He then distributed the mixture into 4 empty drums for his team members.

At around evening time, the workers started roller painting work from a scaffold staging erected in the pontoon tank, with Worker supervising and inspecting the painting work.

Thirty minutes later, a flash fire occurred in the pontoon tank. All 6 workers managed to climb out of the pontoon tanks. However, 4 of them including Painter sustained burns. A few days later, Painter succumbed to his injuries due to bronchopneumonia (lung infection) complications and extensive burns.

Findings

Mission

Painting work: The workers were tasked to carry out painting works in a pontoon tank onboard the oil rig. Their tasks include roller painting works, tank cleaning, vacuuming work and touching up of paint in the pontoon tank (Figure 1).
Machine

15 **Use of non-flame proof lighting**: Non flame proof lighting in the form of electrical cable with filament-type light bulbs were used in the pontoon tank at the time of incident (Figure 2).

16 **Exposed filament in light bulb**: Slightly before the flash fire occurred, some of the workers heard a “pop” that sounded like breaking glass. The bursting of the light bulb resulted in the exposure of the electrical bulb filament. This was likely due to electrical overloading.

17 **Exposed electrical wires in electrical cable**: The electrical cable of the non flame-proof lighting was also found to be in poor condition with damaged insulation and exposed electrical wires at several locations along the cable (Figure 3).
WSH Council

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Man

18 Emission and accumulation of flammable solvent vapours: One of the workers mixed the paint and the hardener inside the pontoon tank. After which, the mixture were redistributed into 4 smaller drums for 4 other workers. All these activities, together with the drying of paint on the tank surfaces caused an increase in the accumulation of flammable vapours in the pontoon tank.

Management

19 Established system to manage risks of fire: The occupier had established a proper system to manage risks of fire in the confined space which includes the following:

- Conducted Vessel Safety Coordination Meeting to prevent incompatible works
- Instituted Permit-to-work (PTW) for painting work
- Conducted risk assessment for painting work
- Provided proper access/egress to confined space
- Conducted periodic gas checks
- Provided fire blanket over the manhole
- Provided force ventilation during painting work

20 Lack of continuous air monitoring of flammable vapour: Only oxygen detectors were provided to the contractors and workers. Such detectors are not suitable for continuous monitoring of LEL.

21 Safety Management System not communicated: None of the workers carried any gas detector at the time of incident even though it was stated in the occupier’s safety management system that at least one of the workers should be equipped with an oxygen detector. Worker claimed that he was not aware of this requirement. This indicates the ineffectiveness in communicating the safety management system to the relevant personnel.

22 Inadequate risk assessment: Even though risk assessment had been conducted, they did not include the use of personal gas detectors for continuous gas monitoring and procedure to avoid mixing of paint inside confined space.

Medium

23 Forced ventilation: Fresh air was supplied into the pontoon tank from an air-cooled dehumidifier blower via a 45cm diameter air ventilation trunk. Analysis has shown that the ventilation air flow was sufficient to dilute any accumulation of flammable vapour if there were no heightened painting activity.
24 ** Presence of combustible / flammable substances:** A number of paint and solvent drums were found in the pontoon tank, including: one 20 litres paint drum, two 4 litres paint drums (one drum is half full), two 4 litres hardener drum (one drum half full), five 4 litres drums filled with mixed compound, and three small drums filled with some thinner. The paint and the hardener both contained combustible solvents. Thinner is also a flammable solvent. Severe and localised burnt marks were observed in the vicinity of drums, indicating that a flash back had propagated back to the drums and burnt the workers.

25 ** Pontoon tank and surrounding:** There was only one access manhole opening (diameter 74 cm) to the pontoon tank. The manhole opening could not accommodate a second ventilation trunk (exhaust ventilation) while allowing workers’ access in and egress from the tank (Figure 4).

![Figure 4: Pontoon tank and surrounding](image-url)
Analysis

Primary Causal Factors

26 Man:

a. Mixing of paint and hardener in the confined space accelerated the accumulation of flammable solvent vapours in the pontoon tank.

b. Distribution of paint into 4 smaller drums also increased the paint exposure surfaces and thus the rate of emission of vapour. In addition, drying of the painted tank surfaces also increased the concentration of vapour in the tank.

27 Machine:

a. Non flame proof lighting with exposed filament and exposed electrical wires probably provided the source of ignition.

Contributory Causal Factors

28 Management:

a. Management did not institute procedures to eliminate the risk of vapour accumulation by avoiding mixing of paint inside the confined space and to reduce the amount of flammable substances in the pontoon tank.

b. Management did not provide flame proof electrical lighting for workers working in the confined space.

c. Management did not provide an effective maintenance regime to ensure that the temporary electrical cables used in the confined space were in good condition.

d. Management did not ensure a continuous monitoring of flammable vapour by providing the workers with suitable gas detectors to check the LEL concentration.
Conclusion

29 The incident occurred primarily due to failure of Man and Machine, with Management being the contributing factor. Man accelerated the accumulation of flammable vapours by preparing the mixture in the confined space. Failure of Machine probably provided the source of ignition from the non flame proof lighting with exposed filament and exposed wires. Management also contributed to the cause of the incident by not instituting procedures to eliminate accumulation of flammable vapours / substances, not providing flame proof lighting with proper maintenance on the electrical cable and not having in place a system for continuous monitoring of flammable vapour. All these resulted in the occurrence of such incident that resulted in the death of 1 worker and injury to 3 others.
Recommendations

30 Prior to the commencement of work, a thorough risk assessment must be carried out to identify all hazards associated with the work, including the increase in flammable vapour from painting activities. Safe work procedures and appropriate measures to eliminate/reduce the hazards, as discussed below could be considered.

31 Flammable substances in a confined space should be eliminate or reduced as far as reasonably practicable. For example, mixing of paint and hardener should be done outside of the confined space. Such safe work procedure should be implemented and included in the risk assessment.

32 Flame proof electrical lighting should be provided in confined space to eliminate potential sources of ignition.

33 Workers should be provided with gas detectors to continuously monitor the concentration of flammable vapour. This should also be included in the risk assessment.

34 Safety Management System should be well communicated to all related personnel, such as the use of oxygen detector in a confined space.

35 Maintenance regime should be established to ensure that any temporary electrical cables used in a confined space are in good condition.

36 Exhaust ventilation is preferred than forced ventilation. However, if exhaust ventilation is not available, Management should ensure that the forced air flow is sufficient to dilute any accumulation of flammable vapours within a confined space at all times. Stronger air flow during heightened painting activities should be considered.
5M - Model

**Man** refers to the specific individual(s) directly involved in the operation’s execution, taking into account his/their reliability (attitude, discipline, psychological factors and physical health) and proficiency (knowledge, judgement and hands-on skills).

**Mission** relates to the task that has to be achieved, including the objectives and the aspects of planning, preparation, operating area and contingencies.

**Management** refers to all those who can influence the control of the operations. It involves the supervision, control and scheduling of the operations. It also concerns with the provision of training and management of the risks associated with the operation.

**Machine** refers to the tools for the operation and its reliability (failure rate, accuracy and dependability) and capabilities (its suitability to the tasks, degree of automation, and ability to provide for the needs of the human).

**Medium** refers to the physical environment of an operation. It includes visibility, weather conditions, density of events, the degree of real-time supervision or control and support and the nature of terrain.