WSH Council Forum
Confined Space
Accident Case Studies

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Reason Model (Swiss Cheese Model)

Active Failures:
These are errors or violations (unsafe acts) that have an immediate adverse effect. These unsafe acts are typically associated with operational personnel.

Latent Failures:
Organisation conditions (often a result of managerial policies and actions) in which its effect are not immediately apparent and may lie dormant for a considerable time.

Adapted from Reason, 1990
Source: The University of Adelaide
Sharing of investigation findings on accidents in Confined Space
Highlight the connection between the lapses that eventually led to the accident.
Preventive measures that could have averted these accidents.
Case 1: Synopsis of Accident

- A worker was carrying out manual cleaning work inside an ISO tank.
- He was found unconscious inside the tank.
- Co-workers quickly extricate him out of the tank and administered first-aid.
- Attending paramedics pronounced worker dead on spot.
- Cause of death – acute toluene and acetone poisoning.
Findings

- The Employer is in the business of manufacture, repair, storage, cleaning & trucking of tank containers.
- 6 ISO tanks were earlier brought into the premises.
- Tank dimension:
  - Length : 6m
  - Width : 2.4m
  - Height : 2.6m
- Each tank has 1 manhole. Internal diameter of manhole is 50cm. This is a *Confined Space.*
Findings

- These 6 tanks were cleaned before sending for repair.
- After repair, Supervisor tasked 3 workers (including the Deceased) to carry out manual cleaning work of the tank, for subsequent re-inspection by 3rd party surveyor.
- Supervisor requested Ops Executive to check on the progress of cleaning works.
Findings

- Ops Executive found a pair of boots near the manhole.
- After removing the blower ducting, he found the Deceased in the tank.
- Deceased was holding a respirator; a container of thinner was found near the Deceased.
Findings

- Thinner was used in the cleaning works. It was found to contain 73.9% toluene and 21.2% acetone.

- Toxicology Report: very high level of toluene 25µg/ml) and acetone (87mg/100ml) in Deceased’s blood – cause loss of consciousness and death.

- The blower was found to supply air into manhole at:
  - Flow rate of 0.96 m$^3$/s
  - Air flow velocity of 12.7 m/s
Findings

- Simulation study conducted using Computational Fluid Dynamics (CFD) software to find out
  
  (i) Air circulation;
  
  (ii) Solvent concentration within tank, after 20mins of work.

- Results showed that air within tank was well-mixed. Average concentration of toluene is 100 mg/m³ (>50% PEL)
Probable Cause of Death:

2 scenarios are possible:

i. **Mechanical blower not in operation** – the concentration of toluene and acetone within ISO tank could reach 800ppm and 350ppm respectively. These combined exposure is likely to result in unconsciousness and death.

ii. **Spillage of thinner during work in the ISO tank** – causing a surge in concentration of toluene and acetone vapours within the tank, resulting in Deceased fainting and continually exposed to the solvent vapours.
Lapses

The Employer has a written safe work operation procedures for

- Tank container washing
- Tank survey on cleanliness
- Permit-to-work [PTW]

There was no written procedures on:

- Gas Testing Procedures
- Emergency Rescue Plan

Site Supervisor applied and approved the Tank entry permit and PTW for touch up work in ISO tank on the day of accident. Site Supervisor conducted the gas checks of the tank.
Lapses

- Site Supervisor not a competent person –
  - had not attended the Confined Space Safety Assessor course;
  - had also not seen the company’s procedures for Tank container washing, Tank survey on cleanliness and Permit-to-work.

- No risk assessment performed to identify potential hazards arising from cleaning work using thinner in confined space. Hence no safety precautions identified during work and during emergency response.

- Wrong type of oxygen gas meter was used by Site Supervisor during gas checks. The gas detector used was meant as a detecting device, not a measurement device.
Lapses

Before the Deceased entered the tank:

- No lifeline attached to him;
- No attendant outside the tank;
- No supervision on him;
- Not fit-tested for the respirator issued to him;
- Did not receive external safety training in CS work as required under *CP84 Code of Practice for Entry into and Safe Working in Confined Spaces*. 
Fatal Accident

Where were the gaps?

Risk Assessment
No RA conducted for cleaning works

Safe Work Procedures
SWP developed for tank cleaning inadequate for confined space work.

Training of Employees
Site Supervisor and the Deceased inadequately trained for their task.

Supervision
No supervision on Deceased during the time of accident

Safe Work Procedures
SWP developed for tank cleaning inadequate for confined space work.
Case 2: Synopsis of Accident

- 4 workers were tasked to spray paint the walls and ceiling of box culvert under a carriageway.
- 3 were killed due to acute toluene poisoning.
Findings

- A foreman brought 4 workers to the site to spray paint the walls of box culvert. He left them to work on their own.

- Tight access into box culvert cell 1.
Findings

Inside Cell 1 of box culvert
Findings

- The workers set up a **blower at the exit end** of the cell 1.
- Working in pairs, worker 1 & 2 sprayed painted the cell for almost 1 hour until they **could no longer endure** the smell, and climbed out.
- Worker 3 & 4 then went into cell to continue the work.
- Worker 1 heard cries for help from both worker 3 & 4. Together with worker 2, they entered the cell to render assistance.
- However, worker 1 felt nauseous and he climbed out of the cell, when he passed out.
Findings

- When worker 1 regained consciousness, he did not see his 3 other co-workers. Hence he went across the carriageway to the exit end of the cell to locate his co-workers. When he reached the exit end, he passed out again.
- Foreman returned and began searching. Found his 3 workers in the cell.
- SCDF arrived and extricated the 3 workers. They were pronounced dead on site.
Findings

Solvent
- Samples of paint/thinner mixture contain toluene, naphtha and other solvents.

Recognising CS
- Failure to appropriate control measures for works carried out in cell (with opening blocked by soil) as a Confined Space.

Risk Assessment
- Not conducted → No SWP
- Workers only told not to smoke while painting, and rest if they feel unwell.
Findings

Access to cell

- No proper means of access provided.

PPE

- Only spray painter provided with a particulate respirator (offers no protection against spray paint solvents).
- No PPE provided for rest of workers.
Findings

- **Cause of death:**

  Toxicology report showed very high levels of toluene in the blood of all the Deceased – ranging from 6.6 µg/ml to 13.2 µg/ml. These levels can cause loss of consciousness and death.

  The pathologist report confirmed the cause of death as cardiac and respiratory failure due to toluene toxicity from the inhalation of paint and thinner fumes in an enclosed space.
Where were the gaps?

- Risk Assessment
  - Failure to recognise work area as Confined Space

- Ventilation
  - Inadequate & Ineffective

- Supervision
  - Not provided

- PPE
  - Inappropriate and lacking

3 workers died
Key Learning Points

Hazard Identification
“RA done?”

SWP
“adequate & appropriate?”

Supervision
“where & what they doing?”

Communication
“everybody knows?”

Emergency Response
“Ready to respond safely?”
Key Learning Points

Always regard the confined space as not safe for entry until proven otherwise.

Source: Wordpress.com
Control Measures - Confined Space

If you really need to go into CS

Don’t be a Hero!
Never assume that you can carry out rescue operation on your own without equipment.

- PPE
- Signages
- Permit to work
- Trained Personnel
- Safe Equipment
- Gas Checks
- Emergency Response
- Standby Personnel
- Ventilation

Be conscious of where the fumes are discharge
Do not simply blow the fumes from one compartment into another closed compartment.
Conclusion

Do your Risk Assessment

But also

Recognise the gaps within your layers of protection
Thank you