CASE STUDY

OISD/CS/2024-25/P&E/14 Dt.: 15/1/25

INTRODUCTION

Title: Explosion and major fire in benzene storage tanks.

Location: Refinery

Loss/ Outcome: Two fatality and one injury

BRIEF OF INCIDENT

A sampler went for sampling in a benzene storage tank (capacity 1000 KL with actual material approx. 523 KL) after receipt of benzene. While the sampler was on top of the tank, an explosion and fire occurred, skyrocketing the fixed roof of the tank. The sampler body was found near the roof, that landed around 20 m away from the tank, just outside the dyke. Another benzene tank (capacity 400 KL with actual material approx. 48 KL) in the same dyke exploded about five hours later while the firefighting was in progress. The roof of the second tank landed around 160m away, on a tree and a parked vehicle, which was crushed. Where the second tank roof landed, a canteen worker fell unconscious and the Refinery Shift Manager suffered injuries. The canteen worker later succumbed.

The fire was completely extinguished after about 10 hours of firefighting, with support of mutual aid partners.

OBSERVATIONS / SHORTCOMINGS

1. In the SOP for sampling, relaxation time required between pumping/ receiving and sampling activity, which is required for low conductive liquids, (clause no.4.7 of OISD-RP-110) was not mentioned.
2. The sample device used in the incident was a SS cage (conductive) with a fibre rope (non-conductive), violating the requirements specified in clause no. 4.7 of OISD-RP-110.
3. Gaps with respect to requirements stated in latest OISD-STD-118 were observed in the dyke in which the affected tanks were located:
   - The dyke did not have roads on all four sides. Road was available only on one side (west) that too at a distance of about 45 m from the dyke and with pipeway in between. Further, during site visit, difficulty in approaching to the firefighting equipment due to improper access and the presence of pipelines was observed.
   - There were tanks in dyke on east side, north side as well as south side in contradiction with the stipulation of tanks layout to be in two rows only.
   - Diameter of three tanks out of the nine was exceeding more than 9 meters. No fire wall protection was existing to prevent spreading of spillages from any of the tank to other tanks in the same dyke.

- The total storage capacity was exceeding 5000 m^3 in a single dyke.
- Manifold of these tanks were inside the dyke.

Further, earth pits were inside the dyke.

4. Being old tanks, none of the tanks including the affected tanks were equipped with inert gas blanketing. Furthermore, the tanks dip hatch lid was neither made from non-sparking material nor lined with non-sparking material.
5. Further, a goose neck vent with flame arrester was provided on the external fixed roof for in-breathing/ out-breathing of the tanks. Design documents of the tanks could not be traced. Hence, it could not be verified whether the goose neck was designed for fire case or not. Also, no adequacy calculation was available.
6. The tanks were bonded and grounded with two earthing connections and the last measured earthing resistance was reported and found within the limits. The earthing resistance check was due in another three days from the day of incident. Moreover earthing & bonding effectiveness on the day of incident could not be guaranteed.
7. An interruption of foam application during firefighting was informally informed, which resulted in eruption of pockets of pool fire across the dyke at several places wherever the foam was breaking, and it was more intense near the second tank which resulted in the explosion.
8. No training record with respect to sample collection methodology and the associated risks was evident.
9. Additionally, no competency requirement except educational qualification of standard 8th/SSC was mentioned in the sampler's contract, which specified for assistance in material transfer, hydrocarbon and crude sampling, etc. under semi-skilled manpower supply category.
10. Awareness level of the hazards and potential dangers from the flammable carcinogenic material, Benzene, was observed to be inadequate when interacted with another sampler.
11. During the review of alarm's history/ activation of gas detectors, it was found that all five benzene detectors (in the dyke area) were activated and triggered high-high alarm after around 25 minutes of incident, indicating that the benzene concentration at ground level increased to alarming level quite after the incident. Hence, it also rules out the possibility of benzene spread due to open valves or leakages at ground level.
12. There was no practice of periodic inspection of internal floating deck of the tank, though there is a requirement for inspection of floating deck of internal floating roof tanks as per clause no. 5.2 of OISD-STD-129. In absence of such inspection, potential seal failure, de-floating of deck, etc. may result in ingress of hydrocarbon into the vapor head space between the floating roof deck and the fixed roof.

REASONS OF FAILURE / ROOT CAUSE

The first explosion was caused by the confined vapor cloud explosion between the floating roof deck and the fixed roof ignited most likely by spark emanating from the dip hatch lid (non-spark proof) or the discharge of static charge of benzene liquid (accumulated during the receipt of material) at the time of sampling activity.

The second explosion occurred due to boiling of material in the second tank, aggravated during the foam application interruption at the incident site.

RECOMMENDATIONS

1. Provision of alternate sampling point other than from tank top to be explored, particularly in all low conductivity hydrocarbons.
2. Gauge hatch shall be non-sparking (or lined with non-sparking material) and self-closing type as per clause no. 4.10 of OISD-STD-108.
3. Prevention of static charge build-up and discharge:
   - Sampling and gauging devices shall be either completely conductive or completely nonconductive. Conductive sampling and gauging devices shall not be used with a nonconductive lowering device like cable, dry clean natural fiber rope etc. as specified in clause no. 4.7 of OISD-RP-110.
   - Extra precautions – beyond normal bonding and grounding – should be explored for handling, transferring, and storing low-conductive flammable liquids.
   - Review the effectiveness of conductive equipment/ earthing system associated with low-conductive flammable liquids on quarterly basis.
   - The flow velocity shall be restricted to the limits specified in clause no. 4.5.1 & Appendix-C of OISD-RP-110 during transfer/ filling operations for static accumulator fluids.
   - Testing of conductivity of material at supply location should be conducted and the same shall be specified in the test report along with a message of caution.
   - Conductivity testing/ analysis and reporting shall be ensured at all stages of transfer of such fluids. MSDS should also cover all relevant aspects.
   - Anti-static additives may be added to increase conductivity.
   - A static electricity dissipation study may be conducted to ascertain the relaxation time for known non-conductive flammable liquids.
4. Gap analysis with respect to OISD-STD-118 shall be carried out and necessary corrective measures shall be ensured.
5. Nitrogen blanketing for internal floating roof tanks/ fixed roof tanks should be considered for storing products like benzene, etc. as per clause no. 4.4 of OISD-STD-108.
6. A procedure for periodic inspection of floating deck of internal floating roof tanks in line with clause no. 5.2 of OISD-STD-129 should be developed. Necessary precautions required during such inspections should be included in the procedures.
7. Gap analysis of existing contract management system, particularly with respect to educational qualification, experience and training requirements, to be carried out with reference to clause 7.3 of Working Group Report and shall be specified in all contracts.
8. Appropriate training shall be imparted to all concerned, including contract workers in line with OISD-STD-154. Records should be maintained for all employees & contractual workers along with a list of personnel who are due for initial/ refresher training.
9. SOP of sampling shall be reviewed. Specific SOP shall be developed for sampling of critical products. All personnel should be sensitized about the relevant hazards and related SOPs.
10. The efficacy of firefighting facilities considering difficult scenarios, double contingencies, critical identified areas, difficulty in approaching, etc. shall be verified periodically through mock-drills.
11. Wherever design documents of storage tanks are unavailable, adequacy of safety features should be established.

PHOTOGRAPHS

Figure 1: Dome of the first exploded tank, outside the dyke.

Figure 2: Dome of the second exploded tank.

Figure 3: Image of the first exploded tank.

Figure 4: Image of the second exploded tank.

Pictures of damaged structures/ equipment after the incident