ISC Safety Lore

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Key lessons from incidents during maintenance on atmospheric storage tanks

Introduction

Atmospheric storage tanks are used in a great variety of industries and the maintenance of those can be challenging. One of the most common hazardous materials held in atmospheric storage tanks are flammable liquids. Atmospheric tanks are used for the storage of liquids at ambient temperature and for the storage of refrigerated liquids. Housekeeping activities, such as repairing, painting, cleaning, welding, grinding and cutting are hazardous actions. Major hazards associated with maintenance of atmospheric storage tanks are related to confined space, flammable or explosive atmosphere. It is therefore important to address these hazards to prevent incidents occurring during maintenance work.

Case 1 – Wholesale and retail storage facility

An explosion occurred in a wholesale and retail storage facility in 2001. Two contract workers were carrying out maintenance operations inside a 5,090 m³ atmospheric storage tank. The closed floating roof tank usually contained premium grade gasoline but it was emptied for the maintenance job. The event occurred during cleaning operations. The activity, performed by employees of an external company, consisted in removing residue from the tank bottom by means of scraping. The most plausible theory is that spark was created by one of the worker's tools (boot soles points, metallic scraper, steel snap hook, etc.). Within an explosive atmosphere, this could have caused an explosion. The two workers were seriously injured in the incident. The tank was not repairable and the operation of the storage facility was interrupted for approximately two months.

Key learning points

The distance of the floating roof from the tank bottom at the time of the accident was approximately 1.2 m. The working space in this situation was limited. The empty tank that exploded normally contained premium grade gasoline. The gasoline vapours which were still in the tank caused the explosion. The tank was equipped with only one manhole. Apparently, when the incident occurred not all the vents were open; it is likely that the atmosphere was not homogenous and that explosive pockets of vapour/air also existed. The ventilation system set up to evacuate gasoline vapours was shut down for the cleaning operations to take place. What is also not always recognised is that gasoline collects in welds, pontoons (of floating rooves), particularly if they are not well maintained, small pits and crevices on the surface of the steel, within the residues on the tank floor. This means that there is a continual production of vapours even after the tank has been emptied. This means that explosive atmosphere measurements need to be regularly repeated as well as constant ventilation. Finally, the limited space of movement of the workers was also an adverse factor in their escape.

Case 2 – Oil refinery

A massive explosion destroyed a large storage tank containing a mixture of sulphuric acid and flammable hydrocarbons at an oil refinery. One contract worker was killed, eight others were injured, and sulphuric acid from collapsed and damage tanks polluted the local river. The explosion occurred during welding operations to repair a catwalk above the sulphuric acid tank, when flammable hydrocarbon vapour was ignited by welding sparks. This resulted in a powerful explosion inside the tank.

Key learning points

On the day of the accident, flammable gas testing was performed only at the start of the hot work, but monitoring was not conducted for the duration of the repair activities. It is also important as to where the explosive atmosphere measurements were made. Through the five hours between the last gas test and the explosion, the ambient temperature raised significantly. This warming caused the hydrocarbons inside the tank to vapourise. The resulting flammable vapour leaked out from corrosion holes in the tank into the work area. The company had a hot work program that included written permits, but the program was inadequate. Hot work was allowed near tanks that contained flammable materials without continuous atmospheric monitoring and the control of welding sparks was not required.

The ISC believes that leadership across six key functional elements is vital to achieve good process safety outcomes. These elements are:

- systems & procedures
- engineering & design
- assurance
- knowledge & competence
- human factors
- culture

In the *What can I do* section below you can see how each of these elements plays a part.

Figure 1: The ISC Framework

What can I do?

Management

- Safety management system with written procedures should be in place to address maintenance activities along with normal operations. Assurance activities are required to get feedback on the safety management system.
- Routine PTW audit programme should be in place with reports, analysis and compliance KPIs. Arguably field auditing should be increased for specific and large tasks such as tank maintenance.
- Contractor selection criteria and competence assurance programmes (one of the PSMSs) which should be in place.
- Identify the hazards and check that safeguards are available and adequate. Make sure that maintenance activities are considered in sufficient detail during PHA/HAZOP reviews.
- Train all personnel including contract workers on maintenance procedures and proper use of flammable gas detectors.
- Make sure that maintenance supervisors have the competence to undertake responsibilities and to perform their activities to a recognised standard on a sustained basis.

Process Engineer/Supervisor

- When issuing a permit (PTW), make sure that all hazards specific to the task are identified and that methods of hazard control are in place. Make sure that operators learn about the hazards and the control measures.
- In addition to the permit, job specific Task Risk Assessment (TRA) is needed for higher risk activities. Any deviations from the PTW/TRA must be risk assessed prior to execution.
- Supervise and control the work; check that the procedures are always followed. Talk through the repair procedure with the workforce before issuing a PTW.
- The atmosphere can change rapidly; continuous gas monitoring needs to be conducted immediately prior to and during hot work activities to ensure that workers are constantly aware of the potential development of an explosive atmosphere. Ensure continuous ventilation is in place.
- Process isolation and preparation plan should be clearly documented.
- Make sure that maintenance work is planned and integrated properly with other work to be done.
- Prepare an emergency response plan to enable workers to escape or act upon in case of emergency.
- Check that all personal protection equipment (PPE) that is required for the work is present and fit for purpose.
- Ensure PTW is handed back on completion of the job, it must be done person to person.
- Be aware that water washing may remove liquid from the tank but not all the vapours or sludge and scale.

Operator

- Make sure that no flammable gas/vapour is left inside the tank prior to hot work activities. Properly test for explosivity, performing gas monitoring before and during hot work.
- Check that you have a fire watch and a fire extinguishing equipment present. Ensure that relevant PPE is available such as breathing apparatus.
- Gasoline collects in welds, pontoons, small pits and crevices on the surface of the steel and within residues on the tank floor. Regularly repeat explosive atmosphere measurements as residue or corrosion is disturbed.
- Vessels should be not only isolated and emptied but also safely ventilated to remove flammable vapours. Before anyone enters the tank make sure that the atmosphere is measured and assessed for explosivity and oxygen content. The air ventilation must be continuous and sufficient to ensure a safe working atmosphere at all times.
- Make sure that the system you work on is properly isolated and locked out (blinded or disconnected and electrical isolation of remote operated valves, to prevent them being operated in error). Do not depend only on valve isolation, because valves can leak.
- Cover and seal all drains, vents, manways, open flanges and all sewers. On completion of the job deisolate all equipment including tank vents.