

**Accident while cleaning an acid gas knock-out vessel in a Refinery**  
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**A. INTRODUCTION:**

A fatal incident occurred at one of the Refinery on 23rd July 2012 at around 1635 Hrs. During the incident a contract employee died while carrying out hydro jetting job of an acid gas knock out vessel in Sulphur Recovery Unit (SRU-A). As reported in the first information report (FIR), the deceased person was found to be in unconscious state at the site of the accident. He was immediately shifted to Hospital where he was declared brought dead at about 1700 Hrs.

**B. THE INCIDENT**

- As part of the ongoing shutdown jobs related to SRU unit at the Refinery, it was decided to internally clean the acid gas knock out vessel with hydro jetting using a rigid lance from outside the vessel. The vessel size is around 0.6 Meters Diameter and height around 1.8 Meters. Due to constructional features of the vessel (About 20 inch dia. opening at the top and demister pad support as internal), entry of the personnel inside the vessel is not possible. In addition to general internal cleaning of the vessel, the prime reason for using the hydro jetting process with the provision of a rigid lance of about 1.5 Meters length was to unplug the fully choked bottom drain of the vessel (As shown in photograph)
- The job of vessel cleaning was started at around 14:30 Hrs. At about 16:35 Hrs production engineer of the plant during his normal field round suspected something wrong and climbed up to the second deck platform from where the hydro jetting of the vessel was being carried out. On reaching the incident site he found the contract man in unconscious state with his head leaning into the vessel. Both the hands of the person were also observed to be inside the vessel clutching the rigid lance used for hydro jetting purpose. The workman was immediately rushed to the Hospital where he was declared brought dead at around 17:00 Hrs.

**C. SOME CRITICAL OBSERVATIONS**

Original bottom drain of the vessel being cleaned had got completely plugged during normal operations of the plant. For draining the vessel, an alternate nozzle (N5) which is at about 0.6 meters height from the dish-end bottom (See mechanical drawing and other photographs of the vessel in following pages) was in use for the last three to four years. Due to choking of the bottom drain there was hold up of hydrocarbon sludge in this portion of the vessel.

- The modification of drain line from nozzle N3 to N5 was carried out by the concerned management without following the Management of

Change process as per OISD 178. P&ID available at site was not updated to depict the change.

- The top manhole cover of the vessel was opened on 19/07/2012 i.e. four days prior to the incident. 100% positive isolation of the vessel was not ensured prior to opening the top cover of the vessel. One of the blinds on the Safety valve bypass line to flare was missed out (See Photograph). Though, this (Not blinding the bypass line) did not result in any mishap during the vessel opening but such lapses are avoidable.
- There is no blinding register maintained for the unit.
- Though the top manhole cover of the vessel was opened four days prior to the incident but the decanting of the stagnant portion of liquid containing concentrated oily sludge inside the vessel could not be carried out as the bottom drain of the vessel is completely plugged. The vessel drain is still fully choked with liquid content visible up to the upper drain nozzle even at the time of investigation.
- It is gathered that there is knowledge gap on the part of personnel responsible for the execution of this job on this count. The aspect that agitation of the oily sludge in the vessel could result in release of higher concentrations of H<sub>2</sub>S along with hydrocarbon vapours above the lower explosive limits (LEL), was not visualized. It is pertinent to note here that no gas test was carried out before as well as during the job was underway.
- H<sub>2</sub>S is known to dissolve easily in water and oil, and it may be released when these liquids are heated, depressurized, or agitated. During the course of the investigation an experiment at the site was performed to demonstrate this aspect. Water was put inside the vessel through a 2 inch fire water hose to see the effect of same on the stagnant portion of the oily sludge present inside the vessel. Within two minutes of opening the water inside the vessel, concentration of H<sub>2</sub>S was measured with the help of a portable H<sub>2</sub>S detector suspended at a height of about one and a half feet from the top of the vessel. The concentration of H<sub>2</sub>S measured was found to be 7.5 ppm. This demonstrates that there is still significant concentration of dissolved H<sub>2</sub>S in the sludge accumulated in the vessel and the same gets released when agitated. It is pertinent to mention here that agitation of this sludge on the day of accident was carried out with the help of high pressure jet streams from the hydro jetting machine which might have resulted in sudden release of much higher concentration of toxic H<sub>2</sub>S.
- Possibility of release of unacceptable high level concentration of toxic H<sub>2</sub>S release from the stagnant sludge contained within the vessel should have been assessed and suitable precautionary measures should have been identified prior to start of the job. For example the person employed for hydro jetting of the vessel should have been equipped with

portable H<sub>2</sub>S detector and other suitable PPEs. He should also have been briefed about the appropriate instructions to deal with any emergency while carrying out the job.

- This aspect assumes all the importance in view of the fact that person carrying out the job was supposed to de-choke the bottom drain of the vessel. To achieve this objective (De-choking of drain line at the bottom of the vessel) the person might have inserted his neck deep inside the vessel which amounts to entry into a confined space. (Please see the attached photograph wherein the possible posture of the person carrying out the job has been made for reconstructing the event.)
- From the evidence gathered at the site it is clear that the job of hydro jetting of this vessel was started through verbal instructions to the vendor from the concerned officials.
- Work permit prepared for the job was not formally issued for execution. This is a serious systemic lapse of the Refinery work permit system as no job should be started without a valid work permit in place.
- Even if one considers that the job was started by the vendor without being instructed to do so, it is all the more serious a matter and needs attention of the top management of the company to review the overall work permit system of the Refinery.

#### **D. ROOT CAUSE OF THE INCIDENT**

Inadequate awareness and deficient assessment of situation Though the vessel top cover was opened four days prior to the incident but the bottom portion of the vessel was still having significant amount of hydrocarbon sludge which contained very high concentration level of dissolved H<sub>2</sub>S as well. Officials concerned with execution of the job were completely unaware about the fact this stagnant sludge had the potential to generate H<sub>2</sub>S vapours along with unacceptable levels of hydro carbon vapours. There was still a large amount of hydrocarbon sludge in the vessel bottom that got agitated in the cleaning process resulting in the release of very high concentration of hydrocarbon and H<sub>2</sub>S vapours leading to the fatality of the workman performing the job.

Inadequate job procedure

While cleaning the vessel the sludge containing hydrocarbons was agitated, this released vapours. No gas test was carried out either prior or during the execution of the job. The job procedure adopted lacked adequate preparedness to deal with any probable exigency during its execution.

Inadequate training for contract workmen

There is no program for proper training of contract workmen to educate them about the hazards of working in H<sub>2</sub>S environment. Interview with few contract

workmen during the investigation revealed that they have never been educated about the exposure limits of H<sub>2</sub>S during the course of their employment. Many of these contract men are regularly working in SRU for years without any awareness about the hazards involved with handling of H<sub>2</sub>S gas.

**E. RECOMMENDATIONS AND LEARNINGS FROM THE INCIDENT:**

- Work permit system of the Refinery needs to be reviewed and strengthened.
- Besides streamlining work permit system it must be ensured that tool box talk is done for such critical jobs handling H<sub>2</sub>S. Following items are to be ensured:
- Positive isolation of the equipment prior to opening the same must be ensured. PSV bypass valve blind was not put prior to opening the vessel.
- Job Safety Analysis for all critical Jobs prior to issue of the permit must be carried out. For example for the present job (wherein the equipment handling toxic H<sub>2</sub>S was involved) all the precautions related to working in a confined space should have been checked prior to the start of the job.
- Adequate safeguard systems need to be developed and implemented for ensuring that no job in the Refinery is carried out without a valid work permit.
- Identification of a comprehensive list of all equipment where such types of cleaning activities are envisaged during normal operations as well as during shutdown of the unit(s). Maintenance/cleaning procedure specific to the equipment should be thoroughly reviewed and learnings from this incident must also be captured in the final reviewed procedure(s).
- All the modifications in the plant should be carried out following MOC procedure as per OISD 178. Drain line modification of the vessel was done without following the MOC procedure.
- Safety competencies of all the personnel including the contract employees, involved with handling of H<sub>2</sub>S handling need to be enhanced by providing appropriate training at regular intervals.