H2S Released From Molecular Sieves After Contact with Water

Three contractor employees died at a natural gas processing plant as a result of inhalation of H2S released during the unloading of molecular sieves from a NGL drier. Two of the victims were trying to rescue the first worker. The incident description and the learning points derived from the analysis of this tragedy are presented below.

Identified main areas for remedial actions are:

- Lack of detailed knowledge of the properties of molecular sieves.
- Inadequate awareness of hazards and management of risks.
- Insufficient and inadequate controls (system of work)
- Ineffective emergency response.

Description of the process

The Processing Plant concerned produces lean gas and natural gas liquids from associated gas from oil wells. This associated gas contains water vapour and H2S. The process involves compression of gas, refrigeration followed by separation of condensed liquids, dehydration of vapours and liquids and final separation into lean gas and NGL by a cryogenic process.

The natural gas liquids are passed through a bed of molecular sieves to remove water prior to the cryogenic process step. When the bed of sieves becomes saturated with water, it is regenerated by passing a stream of hot gas (250 deg. C) through the bed, followed by cooling of the bed with cold gas.

After some 3-4 years the beds have to be replaced. Normal procedure at this location was to dump the sieves, after regeneration, cooling and purging with Nitrogen into a truck for subsequent disposal.

Description of the incident

The drier was prepared for dumping the sieves in a similar way that had been done many times over the previous 20 years. Appropriate safety precautions and equipment were provided for the entry of personnel into the drier in order to remove the top guard and mesh. Removal of the sieves was done by raking them from the drier onto a chute ending

above a high-sided tipper truck. The truck had been wet with water and the dumped sieves had been wetted using a fire hose in order to reduce the risk from any pyrophoric material and to restrict dust in the windy conditions. After a while a mound of molecular sieves had formed at the back of the truck. A contract labourer decided to enter the truck to level the mound by shovelling the sieves to the front of the truck. Entry to the body of the truck was by a ladder behind the cab. After some 10 minutes a second contractor also entered the body of the truck to help. Shortly afterwards he collapsed. The first contractor went to his assistance and was joined by a third contractor who jumped into the truck from the elevated platform on the drier. All three became unconscious and died. A fourth man who climbed the vehicle ladder to see what was happening also became unconscious but was pulled from the area by rescuers. Emergency response was delayed by unclear radio communications.

Incident analysis

Three main events were identified:

- H2S was present in the truck (semi-enclosed space) at sufficient concentration to overcome workers within minutes and ultimately cause death.
- Workers in the truck were unprotected (no SCBA/escape masks/personal monitors)
- Initial emergency response was not effective.

A major contributing condition was also identified:

- There was a lack of awareness of the H2S hazard associated with the dumping of the molecular sieves and thus inadequate management of the risks.

The H2S was evolved (de-sorbed) from the molecular sieves in the truck. The gas used for regeneration of the sieves prior to dumping is a residue gas containing approximately 830 ppm of H2S. The molecular sieves will start to adsorb H2S from the regeneration gas during the cooling of the bed. This H2S will not be removed from the molecular sieves during the Nitrogen purging stage. However, since the affinity of the molecular sieves for water far exceeds the affinity for H2S, the H2S will be released when the sieves are contacted with water (dumping in a layer of water in the truck and spraying with water). Further, during the levelling of the molecular sieves any trapped H2S will be released.

Failings identified were:

- Staff and contractors did not know that H2S could be released from the molecular sieves.
- The information provided by the sieve manufacturer did not give explicit adequate warning of the risk of desorption of H2S after contact with water.
- Contractors could not recall the content of the site safety induction that they had received some years before.
- The effectiveness of this induction was limited (no test, no records, language/literacy problems).
- Over several years the H2S content of the gas had increased but adequate action had not been taken to enhance awareness of staff and contractors of the hazard. The need to

carry escape masks was not recognised, there was no requirement to carry personal H2S monitors.
- Staff did not react to the unpleasant smell which was apparent for some time before the event.
- There were no warning signs in or around the driers indicating the presence of H2S in hazardous concentrations.
- Dumping the molecular sieves, which was supervised by the Civil group, was not included in the planning of the overall molecular sieve replacement by the Mechanical group.
- Multiple jobs requiring different precautions were on a single Work Permit. The requirements of the Company Permit to Work System were not met.
- No job safety analysis (task risk assessment) was conducted for the task of dumping the molecular sieves, and no tool box talk was given.
- There was no Company supervision present at the job location, during unloading of the molecular sieves.
- There was no immediate availability of rescue staff with breathing apparatus and resuscitation equipment
- The immediate first aid response was inadequate.

Lessons to be learned from this incident

- Understanding of the Hazards and Effects Management Process (HEMP) needs to be improved, in particular the relationship between HEMP and the planning of activities through identification of incident scenarios and job safety analysis (task risk assessment).
- Incident scenarios and appropriate job safety analysis (task risk assessment) should be performed with the involvement of first line supervision. Method statements should be prepared which clearly define roles, responsibilities and the controls to be applied. Communication through tool box talks should be carried out.
- Manufacturer's recommended practices for safe handling of molecular sieves should be understood, communicated and applied.
- Safety induction should be tailor made for the target audience, be multilingual if necessary and preferably visual. Effectiveness needs to be checked and recorded and refresher training requirements defined.
- The awareness of the hazard of H2S should be enhanced for all staff and contractors. The effectiveness of such awareness training should be checked and refresher training requirements defined.
- The use of adequate PPE should be enforced, including the provision of warning notices.
- Emergency drills should address a range of scenarios and involve all staff who may have a role to play.