FINAL REPORT

ACCIDENT DESCRIPTION

CAUSES OF THE ACCIDENT

RECOMMENDATION

ACCIDENT DESCRIPTION

On 4th August, 2010 at 13:58:47, a huge explosion happened in carbon dioxide removal section of ammonia unit in a petrochemical complex due to leakage of process gas. Five company workers, unfortunately, were killed because of burning and blast wave and one seriously burned.

The explosion caused the loss of electrical and instrumentation equipment, insulation of the pipelines, some metal structures, and a lot of amine solvent and eventually the company shut down for 50 days. Our research showed that some key factors contributed to the occurrence of the accident.

In carbon dioxide removal section of Ammonia unit, process gas including nitrogen, methane, carbon monoxide, and carbon dioxide, enters the absorbent tower in which CO_2 is separated by active MDEA solvent from process gas. Lean amine solvent enters the top of the CO_2 absorber and semi-lean solution enters in the middle of the absorber by P-2001 pumps.

Two days before the accident, the unit was put in service once again after the packing of the CO_2 stripper replaced. The night before the accident, a leakage was observed in 32-inch semi-lean amine pipeline near the FV-2004 control valve.

Figure 1. Leakage in 32-inch semi-lean amine pipeline

A plate or a cone (nipple) welded on the pipeline can inhibit the leakage without unit shutdown, when there is a minor leakage in the pipeline and its content has no possible risk of fire and explosion. According to standard API RP 2201, welding or hot tapping should not be performed on pipes containing amines. Welding or hot tapping on pipes containing amines, acids, and bases may cause cracking in the weld area or heat affected zone.

In the morning of the accident, relevant groups were required to eliminate the leak during the meeting of the complex; then a 6-inch cone made and welded on the pipeline in order to eliminate the leakage temporarily.

After welding the cone, workers noticed an increase in the leakage. After that, it was decided to make a larger cone to be installed instead of the first one. At 13:57, the fitter together with his hand began separating the first cone but suddenly the severity of leakage increased. Site operator present at the scene reported the accident to the control room when he saw the great increase in leakage. Fitters and then the operator

decided to leave the place and run to the site fence as they see an increase in leakage and pipe shaking. The pipeline suddenly ruptured and Amine with the pressure of 38bar came out of the rupture spot in a way that the fluid spread in a range of 60 meters and hit the people who were present at the scene.

Amine eruption threw away maintenance supervisor, who had tried to escape the accident, in such a way that he was no longer able to escape.

Four other people including the assistant welder, mechanical foreman, welding foreman and operation worker were thrown to the side equipment by amine eruption and they were not able to escape due to the great severity of amine eruption and the resulted weakness and fatigue and the suffocating smell of amine and CO_2. Safety inspector of the unit also thrown away to the reformer section by amine eruption and fortunately, because of his high physical fitness, he managed to crawl to the secure area before the explosion happened and stayed away from the blast radius.

Because of the rupture, more fluid passed through the pump and the pressure flow meter sensed a decrease in the pressure and reported it to the control system.

The controller of control valve started closing to fix the flow at the set point since it was in Auto mode. Amine pressure in the pipeline decreased after the rupture as soon as the valve control started to close. So, liquid line pressure plus the gas pressure inside the tower dominated the pressure of the pump at the point of rupture. Moreover, because of the absence of a check valve in the entrance of the absorber, the gas exited through the rupture point so that the pressure of the absorber decreased from 32 bars to 15.1 bars in a short period.

A cloud of explosive gas filled the unit and the space under the pipelines and by exposing to a source of heat or spark, an explosion took place.

The research group believes that one of the possible sources of ignition and explosion could be air conditioners of analyzer room located 20 meters from the leakage spot. However, other things such as hot surfaces, welding motor and its attached electrical cable could also be the source of the explosion.

The intensity of the blast tossed the workers in the area and eventually killed them. The board men shut down the unit in emergency as soon as the operator reported the situation and after the blast heard. Experts took measures to prevent gas flow to the unit and exit the explosive gas from the rupture spot. At the same time, fire engines and firefighting equipment sent to the place and the fire completely extinguished at 17:11.

CAUSES OF THE ACCIDENT

The research group investigated the probable causes of the accident:

- Rupture spot, which is along the weld line converter, made from stainless steel and the pipe made from carbon steel, which also extended along the pipe. With regard to the previous corrosion of carbon steel packing in disposal tower, designer`s comment on this fact and evidence of corrosion at the scene of the accident, corrosion factor of wet CO_2 is the main cause of this rupture.

Figure 2. Corrosion factor of wet CO_2

- The FV-2004 control valve was a butterfly valve, which passed the flow completely when adjusted on 60%. This caused the flow to hit the lower part of the pipeline and it led to corrosion and more importantly cavitation in that spot.
  In general, all above-mentioned factors caused a decrease in the thickness of pipe at the rupture spot from 19.6 to 3 mm while API-RP2201 standard recommends a minimum thickness of 4.8 mm required for welding on the lines which are being serviced.

Figure 3. The FV-2004 control valve adjusted on 60%

- The reasons for the rupture can be as the following:
  a) A lack of written clear instructions for the working groups and discord between service groups and technical inspection;
  b) insufficient awareness about a severe decrease in the thickness of the pipe caused workers perform welding on the line and then exert mechanical stress to the thin part of the pipeline so the crack became wider and resulted in the rupture.

RECOMMENDATION

- In the processing units, repair work on piping or equipment in service should be done according to the API-RP 2201 and API2009 standards and a written plan should be prepared for each activity. One of the major standard requirements in such cases is measurement of thickness and careful evaluation of corrosion.
- For routine and non-routine activities, relations between different working groups such as operation, maintenance, safety and inspection groups should be determined and the hierarchy and transposition of activities should be clarified. The performance procedure should also be accurately determined and approved by the relevant groups. All groups should anticipate and evaluate possible risks in their activities and provide appropriate solutions to eliminate or minimize the risks. The execution of activities and tasks specified in the program should be accomplished only based on written approval from performers and supervisors.
- The Research group believes that one of the most important factors to be considered is to review the discrepancies between the design and installation. Therefore, it is necessary to review these discrepancies and reevaluate their risks.
- It is recommended to install a check valve in the entrance of absorber to prevent future accidents in ammonia units.
- Hazop study or its update for the processing units based on HSE-321-07 guide is obligatory. In such studies, it is necessary to pay special attention to fluctuations in processing factors such as temperature, pressure, flow, etc. which may cause fire and explosion.
- In process plants, full deployment of management systems such as IMS, OHSAS, HSE and paying special attention to some standard elements such as mechanical integrity, management of change (MOC), risk assessment and corrective measures play an important role in preventing and reducing accidents.

- In order to be ready for confronting the accident, it is necessary to prepare an emergency action plan and carry out special and efficient maneuvers to train the staff for proper reactions in emergencies.
- To promote the knowledge of different operating, maintenance and technical service groups, it is necessary to carry out instructive and efficient courses especially for newly- employed personnel according to API 1200 standard.