

FINAL REPORT



ACCIDENT DESCRIPTION

CAUSES OF THE ACCIDENT

RECOMMENDATION

ACCIDENT DESCRIPTION

At 14:29 on 2nd February 2011, an explosion happened at NF2 propane sweetening unit in a petrochemical complex. Unfortunately, in this accident 17 workers were injured by the blast radius and two people lost their lives because of serious injuries.

Like many of the previous accidents, the accident also happened during the repairs. The accident happened at the time of shift change when all supervising groups had not deployed in its place. Explosion occurred in this accident did not result in a great fire and therefore did not cause a serious damage to the major unit equipment. Only a number of electrical cables, valves, and instrumentation were damaged.

NF unit design was aimed at separating and purifying NGL gases stream in which is one of the main feeds of this petrochemical complex. In this unit, gases in NGLs which consist mainly of ethane and compounds heavier than ethane are separated and then sweetened and dehydrated. In the sweetening unit, sour gas which is humid and liquefied loses its humidity and sour compounds after touching molecular sieve substrates and silica gel of sweetening towers. Then it is stored in order to be finally sent to other units such as olefin Unit.

In every sweetening section of NF unit, there are two similar towers for sweetening and dehydrating of propane and butane. At any given moment, one tower is absorbing while the other being saturated is restoring. In restoration process, it is necessary to open the tower drain for the fluid to be discharged into a reservoir after feeding off the entrance to the tower and regulating the tower pressure. Then hot gas with temperature around 270 °C is put in contact with the molecular sieve substrates to remove water and absorbed sour ingredients. During the repairs in order to ensure the absence of any flammable material, in addition to the above steps, the whole system is purged to the flare.

Two weeks prior to the accident, the furnace responsible for heating the drying gas was out of service due to perforation of the coil. Despite the request of process engineering unit to make the furnace in service during the overhaul, it was not ready

for service on due time. Furthermore, the reservoir for collecting fluid or the sour gas drum was out of service and blanked due to the impossibility of the restoration operation. Therefore, the unit stopped operation in order to initiate the overhaul without furnace and the reservoir for collecting fluid.

The plant was put out of service two days before the accident and due to inability to discharge the liquid and the restoration operation of the towers which took approximately 5 to 6 hours, it was decided that the towers would be purged with nitrogen for two days to ensure the lack of hydrocarbon.

In the morning of the accident, at 10 am and two days after purging tower with nitrogen, the workers started replacing a manual valve with a repaired control valve under the supervision by one of the operators.

This valve is set on the outlet pipeline route at the bottom of restoration tower. When the workers opened the vent valve they noticed gas release. The work is delayed for 3 hours due to the leakage of gas as well as the weight of mentioned valve and the need for a crane to replace it. At about 2 pm when the staff came back to the location, no one became aware of gas release from the vent valve so the staff tried to open the valve screws. They initially opened some of the bolts and after ensuring the lack of gas or liquid in the pipe, completely opened the valve and raised it with a crane.

After opening the valve, one of the workers examined inside the pipe but does not feel the presence of gas fumes and the work continued.

The repaired control valve had a long stem and therefore it seemed that it cannot be installed by the crane. To resolve this problem, a qualified person having a good record in the heavy transport unit decided to install a lift chain to bring up the valve. Due to the unsuitable position of the valve, the person had to stand among the pipes near the ceiling above the valve and then he started working.

Meanwhile the workers noticed some fluid emission from the pipeline. Those present in the place became a little concerned about it but they did not consider the situation as dangerous because as a routine, when an operator issues work permit for an operation, all necessary measures are taken to provide safe conditions. With fluid

loss, the present operator with the help of a worker took firefighting capsules and started splashing powder on the liquid propane which was pouring in order to reduce the amount of risk. As the emergency phone is not working, the operator asked a worker to inform the plant manager in control room and to bring a water hose to the second floor.

The leaking rate gradually increased and liquid propane poured from the second floor down to the first floor and then on the ground and the Unit area and finally evaporated because of high temperature. The volume of exiting fluid increased rapidly so that workers and the operator felt it will be seriously dangerous and decided to leave the place.

Liquid propane flowed from different parts and evaporated quickly and within about 2 minutes filled the surrounding space. An explosive cloud of propane gas surrounded the area and when it hit the crane or welding engine in the place, suddenly a huge explosion happened. The explosion caused small fires in different parts which burn wooden parts of scaffolding, insulation of pipelines and cables. The fire rate was higher in flange spot since the release of gas and liquid propane from the flange lasted a few minutes.

Unfortunately, the worker who was busy installing the lift chain could not escape and was killed by the explosion and fire due to his improper position in the center of the fire. Another newly-employed worker who was next to the welding engine watching liquid propane leakage and formation of the explosive gas cloud was severely burnt and a few days later died in the hospital. The third person who was not a member of this Unit and had just come to the site to see one of his relatives was tossed down by the explosion to the first floor and suffered multiple fractures and severe injuries.

When the fire was reported, firefighters were quickly delegated to the scene and a few minutes later the fire was put out completely since there was no burning matter for combustion.

CAUSES OF THE ACCIDENT

The research group investigated the probable causes of the accident:

- It is essential for every repairing service to make sure that safety of the environment will be considered. When a unit is out of service for maintenance, evacuation and purging operation must be carefully done according to the designer requirements and the HSE department directives. In the units dealing with cold materials such as liquid gas, for repairing purposes, there is a very important stage after liquid evacuation which is called drying.
- In this plant, coincided with furnace maintenance and subsequent inability to carry out the restoring operation, liquid collector tank was put out of service and it was made blind. Although at the time of removal from service, repairing activities were finished and the tank could be in service, unit operators supposed that replacing two very important steps of fluid drain and drying absorption beds with an almost long-term nitrogen purge, can strip the absorption beds from liquids and hydrocarbon gases. But what was not predictable was the formation of gas hydrate. With the starting of putting the unit out of service, liquid propane was not drained because the liquid collector tank was blind. The propane began to evaporate and the tower temperature reduced to below 0 ° C. Since this tower was in service for two weeks without any restoration operation, the molecular sieve substrates and silica gel were saturated with water or at least were nearly saturated with water. Because of the temperature below zero and the positive pressure in the tower and the water in the substrates the gas hydrate was formed. Gas hydrates are like ice crystals and the water in hydrate could store propane 160 times its volume. The injecting nitrogen with the environment temperature created some channels in the mass and removed large amounts of propane during two days. Of course the nitrogen pressure was about 6 times and it has been a factor in hydrate stability. If the hydrate was not formed all the propane could be evaporated and purged to the flare with the nitrogen. But within a few hours on the day of the

accident while the nitrogen purge was interrupted, adsorbent beds in which liquid propane was frozen began to melt and at first the u-shaped part of the tube at the bottom of the tower was filled. While the volume of liquid increased, its vapor filled the space inside the tower and due to the higher air temperature in the middle of the day, the tower pressure increased rapidly. Unfortunately vent route on the top of the tower was not opened because of unknown reasons possibly forgetfulness or a lack of attention. The pressure inside the power increased and as a result it moved up in the pipe. The accumulated liquid slowly leaves the valve flange and the pressure inside the tower goes up gradually and the height of liquid column is reduced and thus the outflow of liquid increased. In fact, the evaporation of liquid inside the absorbents caused pressure on the top of the tower, and since there was no way for the gas to go out, it pushed the accumulated fluid in the pipe toward the valve which was being replaced, and eventually, a fatal accident happened due to a lack of change management principles.



Figure 1. Formation of gas hydrate

RECOMMENDATION

- Different steps of a service operation must be done carefully and completely. In case one step cannot be carried out, all aspects should be considered to remove it. In fact, change management should be considered in the operational plants, and solutions and guidelines based on personal experience should also be avoided. Especially if the changes are related to the process unit, as this accident, process engineering have important role in managing the change.
- To do repairing activities, the working groups should attend to do the required tasks in turn. The type of work should also be prioritized.
- Prior to the overhaul in every petrochemical company, it is necessary to plan the repairs based on actual time needed for each activity, and various meetings with the working groups should be held to discuss everyone's task, and shortening the time of the overhaul to put the plant in service must be prohibited.
- Any stop and restart of the Units should be done in accordance with safe operating procedures (SOP) and every change at any stage of work due to operational problems must be accomplished along with the prediction and risk assessment procedures.
- To ensure all activities related to preparation of equipment in the overhaul period, it is better to carry out all measures according to standard checklists and the records should be registered.
- A program of periodic preventive maintenance (PM) for the control and separator valves should be performed appropriately and with high quality. Lack of proper performance of such equipment not only increases risky activities during the Unit repairs while in service, but also in some cases it is difficult or even practically impossible to perform safe repairs.
- The arrival of new individuals into a process plant is always accompanied by new risks. Therefore, it is necessary to provide appropriate and adequate

training for overhaul staff as well as supervising the staff properly while they are busy working.

- In the hazardous repair work, unrelated persons should not be allowed in, if possible, and to ensure the safety of activities, an operator and standby fire personnel with appropriate equipment, especially communication system, should be present.
- To encourage and motivate the contractors and related personnel regarding the importance of the work without incident, creating financial incentives at the end of the overhaul play an important role in reducing accidents. Moreover, having a comprehensive database of qualified contractors and agents used in the overhaul will help prevent the accidents.
- To promote the quality level of overhaul in petrochemical companies, it is suggested that the quality of performed overhaul is assessed by a third party after the overhaul is over.