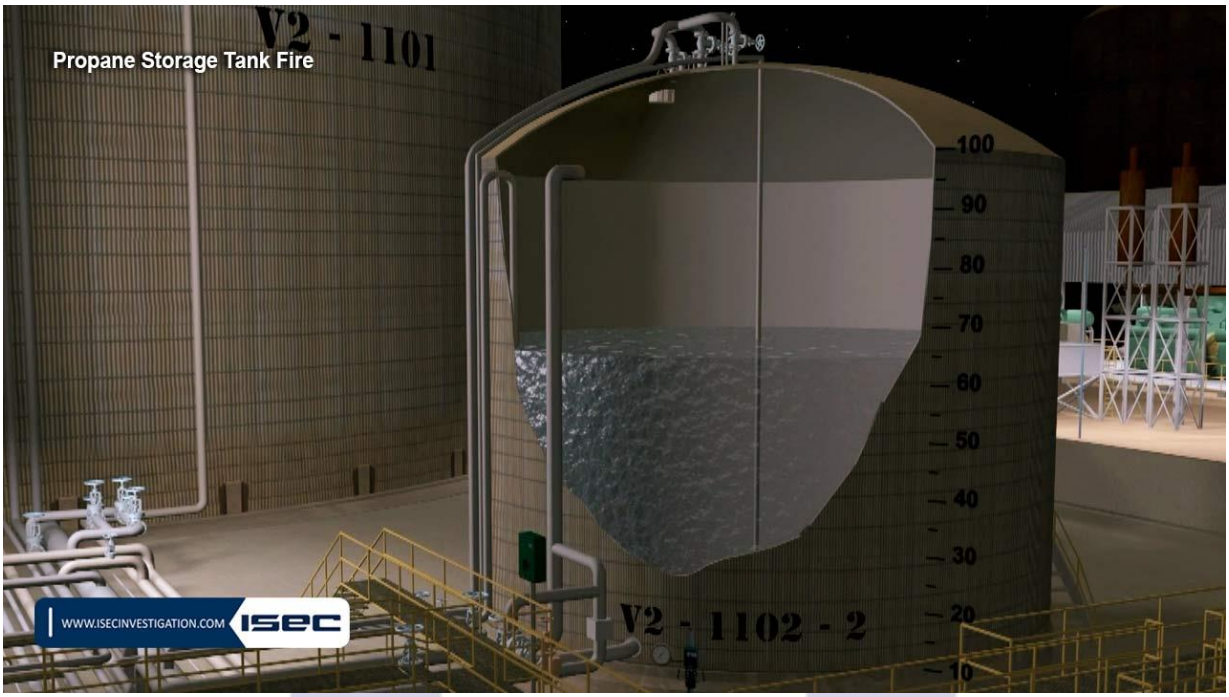
FINAL REPORT



ACCIDENT DESCRIPTION

CAUSES OF THE ACCIDENT

RECOMMENDATION

ACCIDENT DESCRIPTION

On January 13, 2011, at 9:00 pm, an explosion and a huge fire happened at a petrochemical complex due to a rupture in flare line of a 10-thousand-ton storage tank containing propane and resulting gas leakage. Unfortunately, in this accident, the senior operator of the unit was burnt severely and finally died.

When the explosion happened it brought about the following results; loss of wall insulation of propane storage tank for about 500 square meters, damage and rupture to the body of one propane compressor, rupture to the flare line connected to the main tank, damage to the safety valves and safety hatches of the daily propane tanks, damage to electrical and instrumentation equipment, and eventually a pause in the process of propane transfer to the ship due to the compressors shut down for a while.

In this petrochemical complex, for the product of propane, there are two daily tanks with the capacity of 5500 barrels each, and a main storage tank with a capacity of 260000 barrels. Manufactured propane first enters one of the daily tanks, and after laboratory tests and compliance with standard requirements goes to the main reservoir. For testing, first the daily tank is isolated and produced propane is stored in the other daily tank. However, due to the possibility of compressor emergency shutdown and the need for propane to startup, the operation group begins transferring propane from the daily tank to the main reservoironly when the level of the tank is over 50 percent.

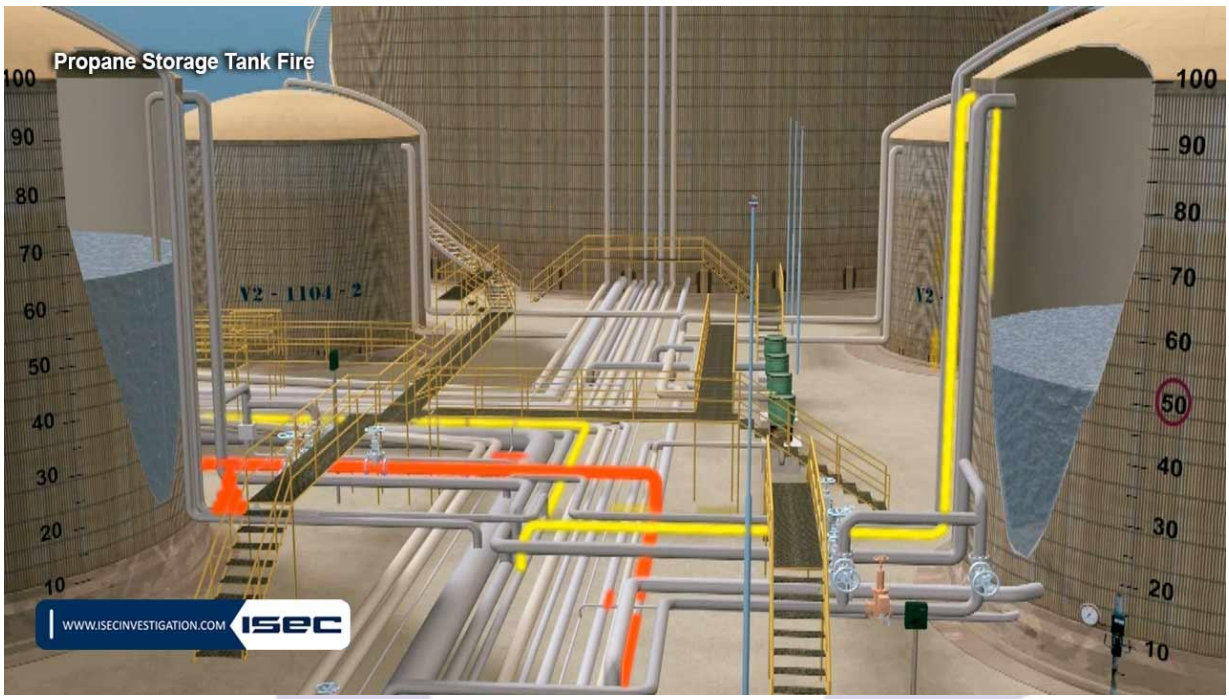


Figure 1. Operation group begins transferring propane from the daily tank to the main reservoir

It is worth mentioning that because of NPSH limitation of the pumps, complete discharge of the daily tank is not practically possible and when the product is unloaded from the daily tank to the main reservoir, 25 percent of the product always remains in the daily tank. Thus, 180 barrels, more than three percent, is added to the tank capacity per hour. As a routine, every 12 hours the loading tank in which liquid level has risen about 65 percent is isolated and rundown is transferred to the second tank. Vaporized gases in each tank are compressed by two reciprocating compressors and after cooling by air coolers and passing through depressor system, the gas is liquefied again and goes back to the tanks. In this route, line pressure is controlled by PCV control valves, and if the line is over pressurized by any reason, the PCV valves will transfer the gases to the flare line.

Three safety valves are installed on every daily and main tank in order to direct propane to flare in case the inside tank is over pressurized. Furthermore, there are

safety hatches on top of the tank to release gas into the atmosphere so that the internal pressure can be controlled.

At 18:30 on the day before the accident, the tank number 2 was isolated for the quality tests and rundown was transferred to the tank number 1. After about half an hour, the quality of product in tank No 2 was confirmed by the laboratory but since the level of propane liquid in tank No 1 had not reached 50 percent, transfer operation to the main tank did not start. Four hours after shift change, at 11 am, the operation of product transfer from tank No 2 to the main reservoir began and when the liquid level in tank No 2 reached 25 percent, the operation was stopped but product transfer to tank No 1 continued and transmitter still showed the liquid level in tank No 1 less than 65 percent at the end of day shift and after 25 hours of loading,

When shift changed and around 19:30, site operator warned the control room as he heard unusual compressor noise. Immediately the senior operator and area supervisor attended the place and after evaluating the conditions and observing that the wall of suction pipe was frozen, they estimate that tank No 1 had overflowed. The senior operator immediately started unloading the first compressor and lowering the second compressor operation. Since the compressor did not have sufficient capacity to return the gas flow, area supervisor together with exploitation operator went to the tanks and brought down the set point of PCVs so that vaporized propane gas went to the flare instead of compressors. Then they changed the operation of product transfer from tank No 1 to tank No 2 and opened the route between two tanks. They then left the place as they suddenly heard a loud sound and noticed gas release from rupture spot in the flare line.

Propane emitted from the rupture spot and explosive vapor cloud was formed quickly. Wind moved the cloud to the combustion engines of compressors as the source of heat and caused the gas to flame and then a sudden explosion of vapor cloud happened. Senior operator who was close to the compressors was tossed by the blast wave but after a short while he became conscious and reported the fire despite being severely burnt. Then he left the place.

The fire at flare line next to the main loading tank, which was initially very intensive, heated the two daily tanks which had the same liquid level after the connecting line between them was opened. This increased vaporization of collected liquid propane and after a few minutes, safety valves acted. As a result, their safety hatches ruptured and led the output gas to flame. Immediately after the fire was reported by the operators, fire teams from the complex, offshore oil companies and oil terminals and urban services began extinguishing the fire and with regard to the huge amount of propane in the main reservoir, they tried to cool the main reservoir. Finally, on Saturday morning the fire was completely extinguished.

CAUSES OF THE ACCIDENT

The research group investigated the probable causes of the accident:

- On the day of the accident, an excessive amount of propane enters the tank and overflows since the level gauge in tank No 1 did not work properly. Then a large amount of liquefied propane with the temperature of -42 which was present in the return line of input gas to the compressor enters the flare line with the environment temperature. This results in heat stress and then a rupture as 12 cm long in the flare pipeline at the welding spot of reducer.
- It is necessary to mention that a landslide at one side of the 10-thousand-ton propane storage tank caused the tank to deviate from the ground level and this led to the separation of pipes from the support section and as a result they were exposed to mechanical stress. The maximum stress was at the convertor spot on the lower part of tank wall. For this reason, the pipeline ruptured at this point because of heat stress.
- Propane transfer tank No 1 lasted more than 25 hours on the day of the accident, although the condition of the unit was normal and the fact that operators knew about the normal product transfer. Despite reporting the prolonged period of testing by laboratory personnel to the production line

group, no one of the group in the successive shifts noticed a system error in instrumentation indicator and they trusted its output data despite knowing about the previous transmitter failure. In fact, the occurrence of human errors in this accident completed the chain of causes of main accident.

- Safety layers and reliable alternative instrumentation systems in operational units are of great importance. Every instrumentation tool may stop working properly and may need to be repaired someday so, this fact should be considered based on the design and operational conditions and also precautions and necessary measures should be predicted in this regard. There were also mechanical level gauges in these tanks as alternative equipment, but due to erosion and lack of periodical repairs they did not work and the tank was working only by one pressure-difference level gauge. This instrumentation tool had stopped working properly seven times on the month prior to the accident. Unfortunately, no measure was taken to overhaul or replace it.
- Although the daily tank should be put out of service in order to overhaul or replace this instrumentation tool but correcting the errors or periodic repairs and updating the equipment in operational units should not be sacrificed by financial profit and mass production.

RECOMMENDATION

- To prevent similar accidents, especially in units with more than 10 years old it is required to update and ensure the proper functioning of equipment and devices especially the tools for measuring the liquid level in the storage tanks and the installed safety systems.
- If a change in the process or equipment occurs, an accurate and comprehensive study should be done about the possible effects and the conditions should be monitored for a while.

- According to API 2030 and NFPA 15 standards, it is necessary to install deluge system near the storage tanks of propane and butane to make sure there is a safe protection layer against heat radiation from fire.
- Observing the walls and inner situation of the tanks based on API 653 standard and using safety valves in compliance with API 510 and 576 standards will eliminate or minimize the risk.
- In order to increase the knowledge of operation, service and technical groups, in such aspects as safety process and issues, it is necessary to carry out effective training programs for working groups, especially for the newly-employed personnel according to the API 1200 so that they could take right decisions in emergencies.
- Monitoring employee's mental status and satisfaction about working conditions in operation units will play an important role in reducing human error factor in industrial units.