STORAGE TANK ACCIDENTS AND ITS PREVENTION IN PETROLEUM INDUSTRY

[1]Pranab Jyoti Sarma, [2]Vikas Pandey, [3]Prasenjit Mondal, [4]P.A. Arun
[1]M.Tech Student, [2]M.Tech Student, [3]Assistant Professor-Selection Grade, [4]Assistant Professor-Senior Scale
[1]Department of Health, Safety and Environment Engineering
[1]University of Petroleum & Energy Studies, Dehradun, India

Abstract: Petroleum is very flammable and volatile in nature and storage of them is quite a challenge to petroleum companies. Hazards like explosion, toxic gas release, asphyxiation are some of the common cases found in petroleum storage tanks and if these incidents or accidents are not investigated properly, they may once again occur in the future. Cleaning and maintenance of these tanks are done only by competent or trained person having valid certificate. Emergency action plan should be prepared and need to be addressed to all the staffs and workers working at the storage tanks in case of any disaster. Since fire and explosion are very likely to occur in such places, firefighting equipment and ambulance need to be arranged by the operator.

Index Terms **- Hazard, asphyxiation, petroleum, emergency action plan.**

I. INTRODUCTION

Storage tank accident is one of the dangerous and life threatening hazard in oil and gas industry. Since it deals with highly flammable substances like crude oil, gasoline, hydrochloric acid and many other toxic substances there is a chance of storage tank to catch fire and explosion. Understanding the type of storage tanks and composition of the hydrocarbon liquid is very much important to deal with safety and prevention of storage tank hazard. Recent major storage tank accidents are Buncefield oil storage in 11 December, 2005(Buncefield Major Incident Investigation Board, 2005) and Caribbean Petroleum refining in 23 October, 2009. In Bhopal, India, release of Methyl Isocyanate(MIC) from the chemical storage tank has led to death of more than 2500 people (Gupta, 2005). Due to negligence and failure of risk analysis during designing of MIC system by the Union Carbide, such tragedy would not have occurred (Khan and Abbasi, 1999). These accidents cause loss of human life, process plant destruction and environmental imbalance and there is a need to prevent it from reoccurring (Pitblado, 2011). In this paper we will try to identify the causes of hazards and accidents in petroleum storage tank and also to find the control measures to deal against them while reducing the loss of human life and injuries.

II. CAUSES OF TANK ACCIDENT

A study of 242 storage tank accident was studied from various papers (Mahoney, 1990) (Persson and Lönnermark, 2004) (Chang and Lin, 2006) and databases have found that lightning was the number one cause followed by maintenance error. These accidents were categorized according to cause and the resultant effect by fishbone diagram (Ishikawa, 1985). We will discuss some of the causes of storage tank accidents below: -

2.1 Lightning

Lightning that causes fires are two types- direct strike and secondary effects like earth current, electromagnetic pulse, electrostatic pulse and bound charge (Carpenter, 1996). If the lightning is a direct strike, then the heat generated causes the flammable vapor to ignite fire. In Gilacap province of Indonesia storage tank containing naphtha was hit by lightning on 24th October,1995 and destroyed property worth $38 million (Coco, 2001). The time taken to recover the plant to resume operation in full capacity was two years.

But the secondary strike fire is more hazardous than direct strike because the lightning charge area absorbed by projecting structure and ground is more than a direct strike. An external roof storage tank in Tanzania containing crude oil of 8 thousand barrel was struck by lightning which resulted in continuous burning for 5 days (Persson and Lönnermark, 2004). Currently there is no fire proof lightning protection available and National Fire Protection Association(NFPA) has yet to find concrete solution for this problem.

2.2 Maintenance Error

Welding can result in fires in storage tank. In 1995, two tank contain flammable vapors explode because of welding operation outside thirty feet diameter tank (Chang and Lin 2006). Another incident where sparks generated from flames in a cutting torch has resulted in ignition of combustible vapor in a storage tank in Greece in 1986(Fewtrell and Hirst, 1998). The fire burned like a wild fire and destroyed ten of twelve tanks and causes loss of 5 people. In an another tragic accident forty plant worker lost their lives when a cleanup operation of an empty liquefied natural gas(LNG) tank exploded in Staten Island, United States of America(USA) (Juckett, 2002). Later on it was found that the chemicals used for cleaning the tank ignited and thus resulted in explosion.

Fires from electrical sparks is also a possibility in storage tank. Sparks from electrical motor had led to accident in Taiwan refinery in 1984 and Lanjou refinery, in China 2002(Chang and Lin, 2006). For removing electrical hazard, classification of hazardous location has already been described in various standards (Fawcett, 1994). Spark is also produced due to mechanical friction which can result in ignition of flammable vapors. In Ponca city, USA 28 October 1999, a man lift with two employees on board generated spark that led to ignition of fire and resulted in complete destruction of cone roof tank (Persson and Lönnermark 2004). In 1996, an accident happened at Chaiyi chemical plant in Taiwan due to spark produce from an electric soldering machine (Chang and Lin 2006).

2.3 Operational error

Overfilling of flammable liquid is one of the common operational error in storage tank. There are some cases of overfilling of flammable liquid like in benzene tank, phenol tank, oil product tank, crude oil tank and gasoline tank which had resulted in big accidents. During transfer of toxic phenol at storage tank in Wrexam, United Kingdom(UK), due to incorrect setting of the pump 14 tons of this flammable liquid was released in a nearby embankment (Whitfield, 2002).

Excess pressure in the pipeline supplying liquefied petroleum gas(LPG) to a plant in Mexico has led to breaking of the line connecting several tanks (Paullin and Santman, 1985). Control room operator was not able to identify the cause of decrease pressure and LPG was

released continuously which eventually led to gas to get ignited at the stack. Five hundred people died from fire and explosion and the plant was destroyed.

Poisonous liquids or fumes may likewise be discharged if administrators commit errors. On 10 September 2001, a huge amount of harmful gas was discharged into the air from a British manufacturing plant, when 300 liter of sodium hypochlorite (NaClO) was incidentally discharged into a tank carrying 6000 liters of hydrochloric acid (HCL) (Chang and Lin 2006). Around 170 specialists were evacuated from that place. A waste holding tank having 2000 gallons of HCL was spilled at Arizona plating plant on Monday 15th of January 2001 and the spillage had entered drains of the nearby industrial park at Western Phoenix. No injuries were recorded since the individuals who worked in the industrial park were evacuated promptly. Overheating due to operational error had led to fire and explosion of a roof company, at Richland, USA in 1997(Chang and Lin 2006).

2.4 Static electricity

Static charge development in the storage tank has led to accident on two occasion in Japan on 1965 and 1972(Takagi, 2004). On both the occasion the operator used devices made of metal or non-conducting thread that were used to connect the tank. Electrical sparks also developed between metal when a pump is connected or ejected.

Static electricity in a chemical plant accident at Taiwan in 1997 was generated due to accumulation of plastic dust in a conveyor (Chang and Lin, 2006). For safe handling of static charge, the tank container need to be bonded and grounded when there is a transfer of flammable fluid.

2.5 Equipment failure

There are many cases of equipment failure in storage tank especially in floating roof tanks. The floating roof depends upon the stability of the rooftop. In a LPG plant in Feyzin, France the discharge valve failed to work and as a result LPG vapors were released. Fire broke out that killed nineteen people and five tanks got destroyed (Garrison, 1989).

Gas explosion due to overheating occurred in Kaohsiung, Taiwan due to defective safety valve in sulfur tank (Chang and Lin, 2006). In Channelview, Texas failure of oxygen analyzer to check the nitrogen in waste water in the petrochemical plant resulted in excess oxygen in the tank and resulted in fire and explosion with significant plant damage. In 1969 an explosion had demolished an oil tank in Taiwan sugar process at Kaohsiung due to heater breakdown. In 1983, fire decimated an oil tank in power plant at Venezuela was caused by failure of thermostat (Chang and Lin 2006).

2.6 Sabotage

There were various instances of militant assaults, instance of fire related crime, and instances of burglary. Amid Iraqi control of Kuwait in 1991, oil storage tanks were sabotaged and set to fire. In 2002 ammonia leak from Washington state nourishment handling plant at Snohomish region and a 2002 leak from Louisiana storage at Bonita was likewise faulted on thieves (Chang and Lin 2006).

2.7 Crack and rupture

Most tank farm degrades owing to old age, erosion and seismic movements. Breaks for the most part happen at the welding edges or base of the storage tank. A 1970 break at the base of a raw petroleum stockpiling tank in Taiwan refinery at Kaohsiung was credited to the moderate subsidence of the establishment (Lin 2003). Both unrefined petroleum spills from capacity tanks into bunds in UK refinery at Hampshire and Taiwan refinery in 2002, were caused due to corrosion at the bottom of tank (Chang and Lin 2006). The 1977 occurrence in Qatar gas handling plant was caused due to welding failure in a tank containing propane (refrigerated) at 45° F (Chang and Lin 2006).

The majority of the spills were confined to territories around the tanks or inside defensive bunds, yet those situated at riverbanks or seashores discharged a huge amount of tank substance into the water. A break of a capacity tank in Pennsylvania terminal at Floreffe, in 1988 discharged 92,400 barrels of diesel into the stream (Chang and Lin 2006) and in 1974 split at the base plate of a tank at a Japan refinery discharged 7500 kilo liter of substantial oil into the ocean (Mohamed 2017).

The tsunami conveyed 1000 barrels of unrefined petroleum into the waterway, after 4 stockpiling tanks burst in a refinery at Mizushima port in December 1983(Chang and Lin 2006). In 1993, an administrator in Taiwan refinery at Kaohsiung tumbled off from a rust opening on the rooftop into the tank (Lin 2003).

2.8 Natural disaster

The harm to an oil stockpiling tank due to earthquake is an unpredictable phenomenon including the attributes of seismic movements, the qualities of the ground, tank structure, the physical characteristics of a substance in storage tank, and so on. All collaborating with each. In 1964, the enormous fire in Japan refinery (at Niigata) occurred due to ignition of hydrocarbon vapors because of sparks produced amid an earthquake (WATANABE 1966). 1978 earthquake brought about the splits of two overwhelming oil stockpiling tanks and one light oil stockpiling tank in Japan refinery at Shiogama. A substantial amount of oils discharged into the ocean (Mohamed 2017).

III. CONTROL MEASURES OF STORAGE TANK ACCIDENTS

The above accidents can be prevented by following certain control measures and preventive actions (Argyropoulos et al., 2012)

3.1 Design of the tank

- Designing of tank should be done as per the standard that is accepted by universal governing bodies such as American Petroleum Institute(API) (Standard, 2002), American National Standards Institute(ANSI) (Anon, 1974), NFPA (Standard, 1996).
- Change or modify the design of tank for prevention from tank being overfilled.
- Computing tank quantity before loading of petroleum to avoid overfilling.

3.2 Maintenance error

- Time to time inspection.
- Testing of overfill alarm system, level indicator.
- Using safety valves and explosion resistant tools according to international standards (DIRECTIVE, 1994).
- Assigning hot work permit to both employees of the operator and also to contractual workers.
- Preventive inspection of venting devices

3.3 Equipment

- Mandatory provision for lightning protection devices.
- Special overflow measuring device.
- Operator should have full control when filling tank.
- Remote facility available for shutting devices.
- Protection against fluid expansion in pipeline against corrosion, static electricity, vibration etc.

3.4 Safety support

- Continuous power supply to the tank operation.
- Fire alarm should be present at all the tanks such that it gets alerted by control room.
- Alarm system also need to be installed in nearby areas of the tank for quick response from fire department.
- Storage of tanks filled with water near potentially flammable equipment during emergency.
- Every petroleum storage tank should have water cooling equipment to prevent fire from spreading.
- Gas detector should be present at a place that can quickly detect gas during overfilling.
- Closed circuit television (CCTV) cameras should be installed near the tanks to detect any abnormal activity.
- Detailed emergency response plan, training of personal protective equipment (PPE) to the workers and material safety data sheet (MSDS) of chemicals should all be present during emergency situations.

3.5 General prevention

- Fencing and walls should be made to prevent any outsider inside the plant.
- Smoking of cigarette should be strictly prohibited near the tanks.
- Flammable liquid carrying vehicles should be kept away surrounding the tanks.
- Special care for prevention of Domino effect to adjacent processes.
- Installing warning sign and labelling near tank sites.
- Adequate firefighting equipment and water available.
- Good housekeeping.

IV. CONCLUSION

After discussing various accidents and control measures of storage tank, we can say that safety of a storage tank is not a simple process. We need to consider various challenges right from designing stage of tank, maintenance, machinery failure, lightning protection and lastly human error. This challenges are interconnected to each other and like Swiss cheese model if one system fails the other will also fail. While technological advances have resulted in fewer accidents in the last decade than frequency of accident occurring thirty years back and storage tank accidents nowadays are mainly due to operator cost cuttings, decreasing quality of equipment used, time saving targets and human error.

In order for a storage plant to run accident free, the operator should conform to all legal requirement and standards. Also safety culture need to be developed from top level of the operating company to workers at the tank farm area because if the leadership does not support safety than why the workers need to. All the required precaution and preventive action need to be taken to avoid storage tank accident.

Timely inspection and audits can increase the safety performance of storage tank because it checks for all the nonconformities and give recommendation for improvement. Many risk analysis techniques have also found to provide good indicator of safety system in storage tanks. Such techniques should be done by person having vast experience and knowledge in the industry. There are still lots of new research going on in this field of study with new fire prevention system and tank safety equipment which maybe in the near future we can completely eliminate hazards and accidents in storage tanks.

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