International Journal of Modern Developments in Engineering and Science
Volume 2, Issue 4, April 2023
https://www.ijmdes.com | ISSN (Online): 2583-3138

Hazard and Operability (HAZOP) Study for LPG Bullet at Heat Treatment Line with BLEVE Dispersion Modelling Using CAMEO

M. Thirunavukarasu[1*], G. Rajesh[2]

[1]M.E. Student, Department of Industrial Safety Engineering, SRM Valliammai Engineering College, Chennai, India

[2]Assistant Professor, Department of Mechanical Engineering, SRM Valliammai Engineering College, Chennai, India

***Abstract*: In this paper, the toxicity-impacted distance of LPG is predicted using the Areal Locations of Hazardous Atmosphere (ALOHA) chemical dispersion model. The model incorporates data on the chemical characteristics of the material, local weather patterns, and release circumstances to predict the sensitive regions that might be toxically impacted by an LPG leak. The nodes are selected for processes plants so that each may have a specific design objective that is relevant, and they are frequently shown on piping and instrumentation diagrams (P&IDs) and process flow diagrams (PFDs). The chemical industry is increasingly using the hazard and operability (HAZOP) research as a tool to identify safety issues in existing facilities as well as plants that are currently being developed or built. The goal of The HAZOP research technique emphasizes the safety component while the LPG bullet is built as a horizontal above ground vessel. The explosive risk associated with LPG is considerable due to its high flammability and (BLEVE) boiling liquid expanding vapour explosion potential. This explosion might result in fatalities and significant property damage; therefore, we used the (HAZOP) hazard operability research approach to identify all pertinent possible risks. We also provided the necessary control measures to lessen or completely eliminate the danger of fire and explosion.**

***Keywords*: LPG Hazop, HAZOP study, BLEVE, VCE, Jet fire, ALOHA, Thermal radiation effects, Dispersion & explosion effects, Dispersion & toxic effects.**

1. Introduction

Process facilities often come with a variety of tools, operating techniques, and control systems. Process plants are vulnerable to process failures and/or accidents if any process deviations from normal operating conditions occur owing to faults in the interplay of equipment, human factor, management, and organisational concerns. Examples of these accidents include the Piper Alpha tragedy, the Bhopal disaster, the Ocean Ranger accident, the Cleveland disaster, the BP Texas City disaster, and the BP Deep Water Horizon explosion. Each accident yielded some lessons, and safety standards and architecture have since been improved. Even with improvements to designs, operations, and emergency protocols, past incidents show that the processing plants are still at risk. Fire, explosions, and hazardous substances are the three primary causes of accidents in processing plants.

A. Objective

This project aims to:

- Suggest a control measure to eliminate/reduce the risk using HAZOP research.
- Reduce the risk in the process activities and risk in the LPG bullet.
- CAMEO® software's estimation of the effects of a catastrophic LPG Bullet rupture.

2. Methodology

Stage-1 Collected the details about LPG Storage Yard
Stage-2 Dispersion Model (ALOHA)
Stage-3 Developing the P&I Diagram for LPG Storage Yard
Stage-4 Node Separation
Stage-5 Control measure using HAZOP Study for LPG storage Yard

Dispersion modelling and a HAZOP analysis have been described in the methodology's process flow. The Areal Locations of Hazardous Atmosphere (ALOHA) is used to forecast the influence of LPG's toxicity on distance. The model incorporates data on the chemical characteristics of the material, local weather patterns, and release circumstances to predict the sensitive regions that might be toxically impacted by an LPG leak. In this case, the LPG storage yard of the manufacturing plant's manufacturing plant, the HAZOP research is performed to identify the specific danger in the specific region, and then by employing of these control measures has been done using HAZOP study.

A. Collected the Details About LPG Storage Yard

LPG Storage Yard Contains two bullets of 14 metric tons capacity gas is used for Canteen and Heat treatment operation. Type of Construction of LPG bullet is Horizontal above ground vessel Storage. Diameter of the vessel is 1.82m and length of the vessel is 5.8m. Design pressure of LPG bullet is 8.50 kg/cm2. Design Temperature of bullet is -6˚C to + 55˚ C. LPG bullets operates at ambient temperature.

*Corresponding author: mthiru34@gmail.com

Table 1
Measurements for the tanker and bullet

Descriptions	Bullet -1	Bullet -1
Length	5.8	5.8
Diameter	1.85	1.85
Volume (m^3)	7.47	7.47

B. Chemical Data

- Chemical name: LPG Molecular weight: 44.10 g/mol. Ambient boiling point: -43.7˚F
- Vapour pressure at Ambient Temperature: >1 atm.
- Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

The information on LPG storage tanks utilised in this study was gathered from a variety of papers and LPG storages from industrial businesses purpose. Bullets with a 14.94 m3 Total volume were selected as the storage option for the investigation. LPG It was presumed that the bullet's storage was above ground level and that it was packed to 85% of capacity. The pressure exerted by the bullet was around 2 kg/cm^2 (28.4467 psi).

C. Data Used to ALOHA

A single storage building in Chennai. An elevation of 130 m is taken into account for the ALOHA modelling of dispersion. The East-West wind direction, travelling at a speed of 15 Knots, was selected as the wind's atmospheric condition. The terrain's roughness was interpreted as wide country with some cloud cover.

3. ALOHA Results and Discussion

A. BLEVE Thermal Radiation

Expanding vapour when boiling liquid Explosion, also known as BLEVE, is a physical event that can place when storage containers are exposed to the outside environment, lasts for a short period of time, and has the potential to result in a very serious mishap. Figures 1 and 2 depict the impacts of Bullet-1 BLEVE and Bullet-2 BLEVE, respectively.

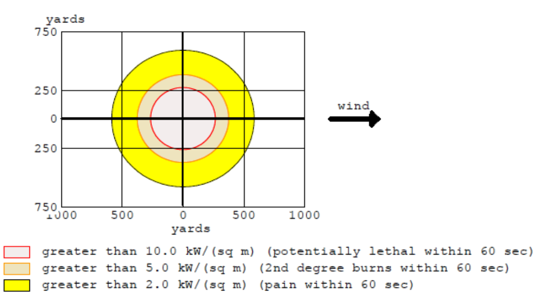

Fig. 1. LPG Bullet-1

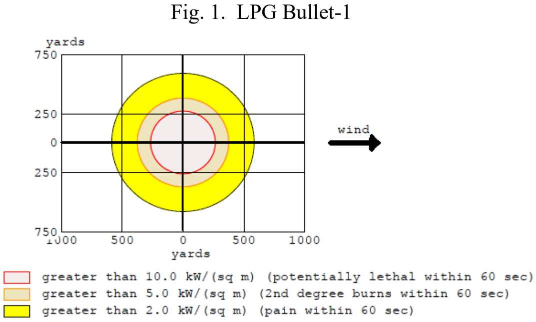

Fig. 2. LPG Bullet-2

B. Jet Fire Thermal Radiation

Jet fires, which often have localised impacts, are among the other types of flames. This may occur as a result of the discharge of restricted or dispersed flammable liquids. This burns like a jet and emits heat after being set ablaze by outside causes. Depict the bullet jet fire and tanker jet fire heat radiation levels, respectively. The Circular-shaped Tank Damaged at dimensions 3cm diameter and 15 cm Height from the Bottom of the tank. It is suspected that outside factors ignited the jet.

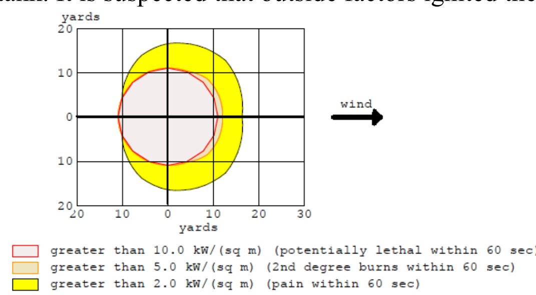

Fig. 3. LPG Bullet-1

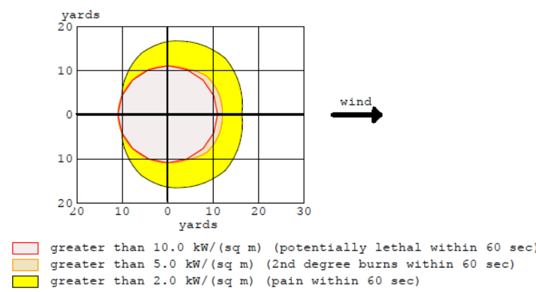

Fig. 4. LPG Bullet-2

C. Flammable Threat Zone Level

Flammable Threat Zone Level shows, which often have localised Fire impacts. It is predicted area where the ground-level vapour (fuel) concentration in air is within the flammable range and can be ignited.

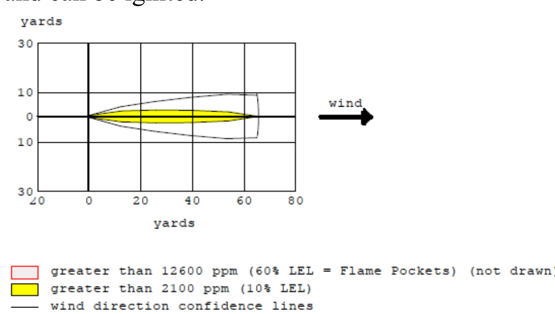

Fig. 5. Bullet storage-1

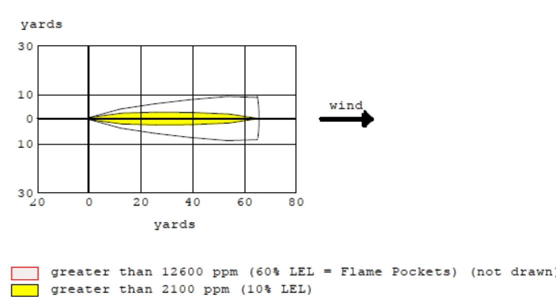

Fig. 6. LPG bullet storage thermal fire radiation

D. *Flammable Threat Zone Concentration Level*

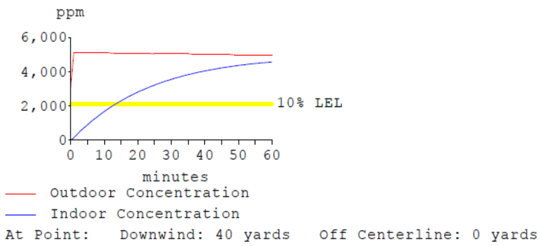

Fig. 7. Flame concentration level

E. *Over Pressure (Blast Force) Threat Zone*

Blast Area of Vapour Cloud Explosion is predicted area where the blast force (overpressure) from the explosion is hazardous.

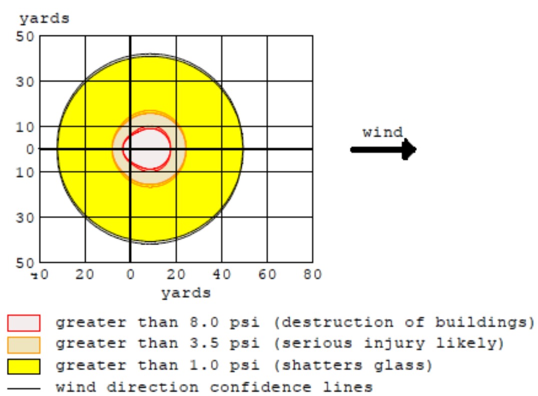

Fig. 8. Over Pressure (Blast Force) threat zone

F. *P&ID Diagram*

(Confidential Diagram Detail) It shows that water is supplied to the LPG Bullet tank under controlled pressure. Pump is used to maintain the required pressure and flow control valve is used to regulate the amount of flow to achieve optimum performance. There is a by-pass line to arrest the leaks from the tank. In vaporizer tank LPG is obtained as gas form to supply gas to the furnace. The LPG gas supply to furnace through the pipe line named as service line.

Nodes are separation,

- Transferring LPG up to inlet valve v1
- Transferring LPG from node 1 (before v1) to node 2
- Transferring LPG from node 2 to node 3
- Transferring LPG from node 3 to node 4
- Transferring LPG from node 4 to node 5
- Pumping liquid LPG from loading tanker to storage bullet
- Transferring high pressure LPG to bullet B1
- Transferring LPG from bullet B1 through service line
- Transferring LPG from bullet B2 through service line
- Circulating heated LPG to service line

G. *Guide Words and Deviations*

Table 2

Guideword		Parameter		Deviation
NO	+	FLOW	=	NO FLOW
MORE	+	PRESSURE	=	HIGH PRESSURE
AS WELL AS	+	ONE PHASE	=	TWO PHASE
OTHERTHAN	+	OPERATION	=	MAINTENANCE

Table 3
HAZOP report sample

NODE 1

SI.NO	INTENTION	GUIDE WORD	DEVIATION	CAUSES	CONSEQUENCES	ACTION
1.	Transferring LPG up to inlet valve v1	No	No flow	-Block between tanker outlet and the liquid line -Operator forgets to open the tanker valve	- No supply of LPG into the liquid line -High pressure rise in the pipe line -Pipe bursting (tanker) Fire and explosion	-periodical maintenance of pipeline (cleaning) -fixing PRV and pressure gauges in pipeline
		Less	Less flow	- leak in the tanker -leak in the liquid line between tanker and valve V1 -Blockage in pipeline	-Vapour cloud formation -Vapour cloud explosion -High pressure pipeline burst follows with fire and explosion	-Emergency alarm system -Low level warning system
		More	More flow	Uncontrolled valve opening (valve failure)	-Sudden Pressure rise in the pipeline from tanker to valve V1. -Pipe rupture due to pressure rise. -Vapour cloud formation, pipe bursting, fire and explosion	-PRV in pipeline -Gas leak sensor -Pressure gauge -emergency alarm system -periodical cleaning and maintenance -Install level indicator -Install PRV -Pressure monitoring system

4. Result and Discussion

An ERPG-1 level of 2100 ppm indicates a quantity that is detectable owing to odour, discomfort, and irritability. People might be exposed for up to an hour without suffering any negative health effects if the amount of airborne concentration was below the upper limit anticipated for each zone (ERPG-1, ERPG-2, and ERPG-3). Typically, the chemical's airborne diffusion causes poisonous clouds to disperse. On the basis of air turbulence, the chemical is carried mostly in the direction of the wind but also perpendicular to the wind.

It is clear by comparing the results of the LPG leak ALOHA modelling in four distinct weather scenarios that the impacted area of the danger will depend on the local weather at the time of the event. a variant depending on the weather, may be noticed in the impacted distance as well as the plume breadth. When comparing two distinct seasons, winter has a higher influence on distance than summer does.

When the time of occurrence is considered, it is shown that the morning is riskier than the evening since it exhibits a greater influenced distance. This study also suggests that the steady atmospheric state, E, is the most hazardous in the event of a chemical spill because a huge number of individuals are exposed to increased risk due to the poisonous vapour cloud of LPG being easily distributed far from the point of release.

Control measures:

- Replacing the pipeline's PRV and pressure gauges
- A security mechanism
- Third-level warning system

- A method for measuring pressure
- Improving the pipe's surrounding support
- Sensors, an automatic fire suppression system, and a firefighting system
- Installing a flow level sensor in the pipeline is step.
- Repairing the system for automated fire detection and suppression
- The pump's overflow sensor and tripping circuit
- Installing a temperature sensor
- An additional heater in the vaporising chamber
- Adding a pressure sensor to the vaporizer room.
- Providing a compressor after the room with the vaporizer.

5. Conclusions

Utilising Areal Location of Hazardous Atmosphere (ALOHA), dispersion modelling is done for LPG storage in the heat treatment plant. When a pressure vessel holding a superheated liquid or liquefied gas suddenly loses containment, it might result in a boiling liquid expanding vapour explosion (BLEVE). Large amounts of pressurised, extremely hot liquid are suddenly released into the environment. Overpressure has two effects on people: direct effects on internal organs and indirect effects from structural debris. The identification of places affected by BLEVE risks is aided by consequence analysis. There is HAZOP research that separates causes, effects, and control options. The cost comparison of losses sustained as a result of accidents and the adoption of mitigation are suggested as suggestions to lessen accidents.

References

[1] N.S. Anjana and A. Amarnath, "Toxic hazards of ammonia release and population vulnerability assessment using geographical information system." Journal of Environmental Management (2018).
[2] Rupesh Kumar Malviya and Muhamed Rushaid, "Consequence Analysis of LPG Storage Tank." Materials Today: Proceedings, 5(2018) 4359–4367.
[3] Ilyas Sellamia, Brady Manescauc and Khaled Chetehouna, "BLEVE Fireball modeling using Fire Dynamic Simulator (FDS) in an algerian gas Industry." Journal of Loss Prevention in the Process Industries (2018).
[4] Hariprasath M, Sathyanathan M and Visagavel K, "Risk Analysis (HAZOP Study) for a Hazardous Chemical Storage Plant." Advances in Natural and Applied Sciences (2017).
[5] Juliane Fiates a, Raphael Ribeiro Cruz Santos a and Fernando Fernandes Neto, "An alternative CFD tool for gas dispersion modelling of heavy gas." Journal of Loss Prevention in the Process Industries (2016).
[6] Azmi Mohd Shariff et. al, "Assessing the hazards from a BLEVE and minimizing its impacts using the inherent safety concept." Journal of loss prevention in the process industries, 41(2016) 303 – 314.
[7] Jianxin Kang and Lijie Guo," HAZOP analysis based on sensitivity evaluation." Safety Science (2016).
[8] Hamidreza Haghnazarloo and Mehdi Parvini," Consequence modeling of a real rupture of toluene storage tank." Journal of loss prevention in the process industries." (2015).
[9] Rahul Parmar, Vivek Shukla, "Evaluation of Hazards by Event Tree Analysis and Assessment of Toxicity Index using Aloha in Pharma Industry", International Journal of Scientific Research & Engineering Trends, Volume 4, Issue 4, pp. 759-764, 2018.
[10] V. N. Dev Kumar, N. Rajasekaran, "Consequence Analysis on Hazardous Locations", International Journal of Advance Research in Computer Science and Management Studies, Volume-04, Issue-04, Page: 165-175, April 2016.
[11] Mohammad Hosein Beheshti, Somayeh Farhang Dehghan, Roohalah Hajizadeh, Sayed Mohammad Jafari4 and Alireza Koohpaei "Modelling the Consequences of Explosion, Fire and Gas Leakage in Domestic Cylinders Containing LPG", Annals of Medical and Health Sciences Research journal, Volume-08, Special Issue-01, Page: 83-88, 2018.
[12] Vishnu V, Mary C Kurian, Boby K George, "Dispersion Modelling for Risk Assessment", International Research Journal of Engineering and Technology, Volume-03, Issue-08, Page: 1746-1752, Aug-2016.
[13] J.M. Tseng, T.S. Su, C.Y. Kuo, "Consequence evaluation of toxic chemical releases by ALOHA", Journal of Procedia Engineering, Volume-45, Page: 384 – 389, 2012.
[14] Haidar Adnan Ibrahim, H. S. Syed, Pavan Shah, 2015. "Quantitative risk assessment for ethylene oxide storage tank in Shree Vallabh Chemical in Ahmedabad", International Journal of Advance Engineering and Research Development, Volume-2, Issue-12, December-2015.
[15] Muhaidheen, M and Muralidharan S., "Performance investigation of power quality in distributed generation system Fed smart grid using different control strategies," Journal of Electrical Engineering, vol.17, no. 2, pp. 1-12.
[16] Hyo Eun Lee, Jong-Ryeul Sohn, Sang-Hoon Byeon, Seok J. Yoon and Kyong Whan Moon, "Alternative Risk Assessment for Dangerous Chemicals in South Korea Regulation: Comparing Three Modeling Programs", International Journal of Environmental Research and Public Health, Volume-15, Page:1600, 2018.
[17] R. Bhattacharya, V. Ganesh Kumar, "Consequence analysis for simulation of hazardous chemicals release using ALOHA software", International Journal of ChemTech Research, Volume-08, Issue-04, Page: 2038-2046, 2015.
[18] Yadhushree B.J, Shiva Kumar B.P, Keerthi D'Souza, 2017. "Qualitative Risk Assessment and HAZOP Study of a Glass Manufacturing Industry", International Journal of Advance Research, Ideas and Innovations in Technology, Volume-03, Issue-04, Page: 776-787, 2017.
[19] Maniram Kumar, S. Rajakarunakaran, P. Pitchipoo, R. Vimalesan, "Fuzzy based risk prioritisation in an auto LPG dispensing station", Journal of Safety Science, Volume-101, Pages: 231-247, 2018.
[20] Muhaidheen, M and Muralidharan, S 'Performance investigation of power quality in distributed generation system Fed smart grid using different control strategies', Journal of Electrical Engineering, vol.17, no. 2, pp. 1-12.
[21] H. Silva Júnior, N.L. Santos, G.A. Fernandes, T.J. Lopes, "Analysis of Consequence Applied to Hypothetical Scenarios of Accidents with Industrial Leakage Of Hydrogen Sulfide Using Aloha 5.4.4® Software", International Journal of Research in Engineering and Technology, Volume: 07, Issue: 02, Page: 88-97, 2018.
[22] IS-11137 (Part 2): 2012 Analysis Techniques for System Reliability-Procedure for Failure Mode and Effects Analysis (FMEA).
[23] IS-15550:2005 -Failure Mode Effects Analysis.
[24] Muhaidheen, M and Muralidharan, S 'Performance investigation of power quality in distributed generation system Fed smart grid using different control strategies', Journal of Electrical Engineering, vol.17, no. 2, pp. 1-12.
[25] James I. Chang, Cheng-chunglin, "A Study of Storage Tank Accidents", Journal of Loss Prevention in the Process Industries, Volume-19, Page: 51–59, 2006.
[26] "The CAMEO Software Suite, ALOHA example scenarios", U.S. Environmental Protection Agency and National Oceanic and Atmospheric Administration, September 2016.
[27] Muhaidheen, M., and B. Meenakshi Sundaram. "A fuzzy logic controlled sliding mode control (SMC) of inverter in shunt active power filter for power quality improvement."
[28] international journal of electrical and power engineering 2, no. 6 (2008): 398-402.
[29] Muhaidheen, M. "New application of M2M in railway protection." In Conference on Computational Intelligence and Multimedia Applications, 2007. International Conference on, vol. 4, pp. 110-114. IEEE, 2007.
[30] Muhaidheen, M., and S. Muralidharan. "A novel Fuzzy based control scheme for Power Quality Enhancement in Grid connected system." In Applied Mechanics and Materials, vol. 573, pp. 304-309. Trans Tech Publications, 2014.
[31] Muhaidheen, M., Muralidharan, S, Bindu, J., and S. Selvaperumal " Particle Swarm Optimization based Selective Harmonic Elimination in PWM AC-AC Converter." Third International Conference on Advances in Electrical & Electronics, vol.01, pp. 41-57. ACEEE, 2012.
[32] M. Muhaideen, B., Satheesh Prabu, and S. Muralidharan. " Design and Development of Z-Source Inverter in DGS Environment" International

Journal of Applied Engineering Research, vol.10, no.09, pp. 7463-7468, 2015.
[33] M.Muhaidheen, K. Prabakaran and S. Muralidharan. "Design and Development of Power Conditioning Circuit for Fuel Cell Environment" International Journal of Applied Engineering Research, vol. 10, no. 9, pp. 7507-7511, 2015.
[34] S. Muralidharan, S. Ravikumar and M. Muhaidheen, "Performance Investigation of Shunt Active Power Filter Under Various Control Strategies in Distribution Generation Source (DGS) Environment " International Journal of Applied Engineering Research, vol. 10, no. 9, pp. 7477-7482, 2015.
[35] M. Muhaidheen, S. Muralidharan and M. Anandhan, "Electrical Safety System for Industry/Residential Applications," International Journal of Mechanical Engineering and Technology (IJMET), 9(9), 2018, pp. 755-760.
[36] M. Muhaidheen and S. Muralidharan, "Internet of Things Based Advanced Security System for ATM," International Journal of Mechanical Engineering and Technology, 9(8), 2018, pp. 722–726.