https://doi.org/10.26552/com.C.2016.1.85-88

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THE LOCATION OF LPG FILLING STATIONS AND POTENTIAL RISKS OF INCIDENTS

The risk of unsuitable placement of LPG (i.e. Liquid Petroleum Gas) propane-butane filling stations in densely populated areas or in the immediate vicinity of busy roads may have, in the event of fire or explosion, incalculable consequences in terms of fatal or serious accidents and cause considerable economic damage to property. As a consequence, the positioning of any such LPG filling station should always be of crucial importance already in the filling station planning stage and its placement should be carefully assessed. The present paper aims at outlining a particular method of evaluating risks resulting from incorrect placement of an LPG filling station, including potential consequences. One such approach to assessment of installation safety of LPG filling stations is to implement the so called ALOHA screening method. This paper shall demonstrate practical implementation of the ALOHA screening, and that with regard to infrastructure, it is not always possible to find a suitable and safe location for LPG filling stations.

Keywords: *ALOHA, safe LPG filling station location, emergencies, safe distance.*

1. Introduction

The purpose of the following section is to describe, with the use of a model situation, the placement of an LPG filling station (Fig. 2) and to stress the importance of paying particular attention to safe placement of this installation for risks and incidents elimination with respect to the infrastructure, the occurrence of incidents and their adverse effects.

The word 'incident' in the context of the presently discussed situation conveys the extraordinary conditions and impact on the affected area, as well as on general public. The magnitude of the incident is the consequence of destructive effect and the nature of the affected area [1].

The consequences of the emergence of extraordinary conditions are numerous and they may be classified according to the following Fig. 1:

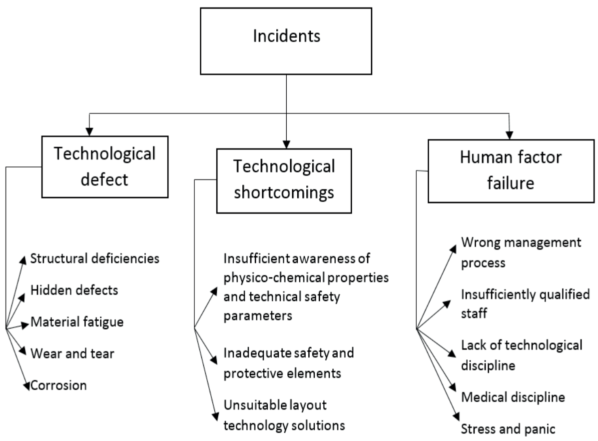

Fig. 1 The Emergence of Incidents [1]

For practical modeling of the ALOHA screening, a fictitious LPG filling station situated in a populated urban area close to a shopping center was chosen. The location of the LPG filling station was specified by a 50-metre distance from the shopping center and 10 meters from the road with normal city traffic. In terms of technical specification, a single-dispenser-unit

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LPG filling station was considered, with a 4000-liter reservoir. The application of the ALOHA method will demonstrate the importance of resolving the matter of safe location for the LPG filling station prior to any construction works.

Fig. 2 An illustrative photograph of an LPG filling station (source: author - O. Varta)

2. ALOHA Screening Method and its Features

The ALOHA software application (Areal Locations Of Hazardous Atmospheres) is a dispersive model for Windows operating system that was developed by the United States Environment Protection Agency (US EPA) [2].

The software uses a series of Gauss distribution equations to evaluate the movement of pollutants released into the air.

The software works with inputs specified in the following fixed order:

- Site location data (place name, country, type of buildings);
- Information on the released agent (the software has a large database of chemical substances, including the necessary physical and chemical properties);
- Information on the state of atmosphere (the grade of air temperature stratification stability following the Pasquill's scale, wind strength and direction, air temperature, degree of cloud cover, etc.);
- Information on the source of the leakage; it is possible to enter 4 source types and their parameters (direct source, puddle, reservoir, pipeline).

The ALOHA software allows to have results in both textual and graphic form. It renders a cloud of an agent of specified concentration, dosage, and source capacity.

The limitations of the ALOHA software include:

- The software works with low wind velocities and stable atmospheric conditions;
- Small resolution of terrain topography;
- The software does not take into account changes in wind direction, impact of fire and chemical reactions, dispersion of solid particles and/or solutions;
- The agent leakage time is set to a period of 1 hour and the dispersion distance is restricted to 10 km.

The latest version of ALOHA software (5.4 of February 2006) added fire and explosion modeling functionality.

Apart from threats of toxicity, users may also evaluate fire hazards associated with the so called jet fires, puddle fires, vapor cloud explosions (VCE), boiling liquid expanding vapor explosions (BLEVE) and flashfires.

The ALOHA software is available free of charge on the US EPA official website [3].

3. Practical Steps for the Use of the ALOHA Method

The location selected for the LPG filling station was Opava, Moravian-Silesian Region, Czech Republic, random choice from the main streets available in this town. The practical calculation example involves toxic cloud dispersion and BLEVE explosion modeling (see Fig. 3 and 4).

4. Calculation pursuant Toxic Cloud Dispersion

SITE DATA:

Location:	TOWN CZECH REPUBLIC
Building Air Exchanges Per Hour:	0.59 (unsheltered single storied)
Time:	December 11, 2014 0931 hours ST (using computer's clock)

CHEMICAL DATA:

Chemical Name:	PROPANE
Molecular Weight:	44.10 g/mol
AEGL-1 (60 min):	5500 ppm
AEGL-2 (60 min):	17000 ppm
AEGL-3 (60 min):	33000 ppm
IDLH:	2100 ppm
LEL:	21000 ppm
UEL:	95000 ppm
Ambient Boiling Point:	-42.7° C
Vapor Pressure at Ambient Temperature:	greater than 1 atm
Ambient Saturation Concentration:	1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind:	3 meters/second from 50° true at 3 meters
Ground Roughness:	urban or forest Cloud Cover: 5 tenths
Air Temperature:	20° C
Stability Class:	D
No Inversion Height	
Relative Humidity:	50%

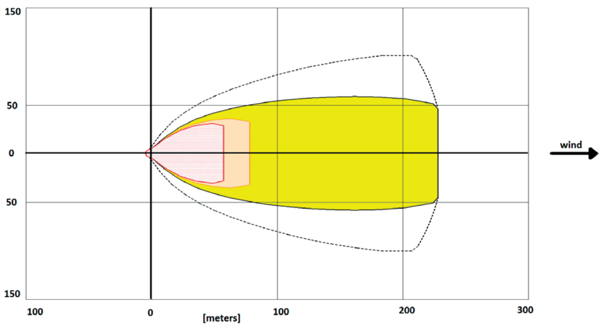
SOURCE STRENGTH:

Leak from short pipe or valve in horizontal cylindrical tank	
Flammable chemical escaping from tank (not burning)	
Tank Diameter:	1.8 meters
Tank Length:	1.57 meters
Tank Volume:	4.00 cubic meters
Tank contains liquid	
Internal Temperature:	20° C
Chemical Mass in Tank:	1.88 tons
Tank is 85% full	
Circular Opening Diameter:	5 centimeters
Opening is 0 meters from tank bottom	
Release Duration:	3 minutes
Max Average Sustained Release Rate:	755 kilograms/min (averaged over a minute or more)
Total Amount Released:	1,706 kilograms
Note:	The chemical escaped as a mixture of gas and aerosol (two phase flow).

THREAT ZONE:

Threat Modeled:	Flammable Area of Vapor Cloud
Model Run:	Heavy Gas

DISPERSION CLOUD RESULTS



Red: 58 meters – (21000 ppm = LEL)
Orange: 79 meters – (12600 ppm = 60% LEL = Flame Pockets)
Yellow: 229 meters – (2100 ppm = 60% LEL)

Fig. 3 Affected area in the vicinity of the LPG filling station [4]

5. BLEVE- Boiling Liquid Expanding Vapor Explosions

SITE DATA:

Location:	OPAVA, Tesinska ulice CZECH REPUBLIC
Building Air Exchanges Per Hour:	0.59 (unsheltered single storied)
Time:	December 11, 2014 0931 hours ST (using computer's clock)

CHEMICAL DATA:

Chemical Name:	PROPANE
Molecular Weight:	44.10 g/mol
AEGL-1 (60 min):	5500 ppm
AEGL-2 (60 min):	17000 ppm
AEGL-3 (60 min):	33000 ppm
IDLH:	2100 ppm
LEL:	21000 ppm
UEL:	95000 ppm
Ambient Boiling Point:	-42.7° C
Vapor Pressure at Ambient Temperature:	greater than 1 atm
Ambient Saturation Concentration:	1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind:	3 meters/second from 50° true at 3 meters
Ground Roughness:	urban or forest
Cloud Cover:	5 tenths
Air Temperature:	20° C
Stability Class:	D
No Inversion Height	
Relative Humidity:	50%

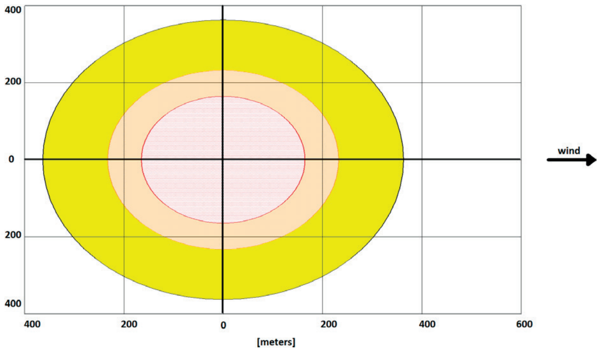
SOURCE STRENGTH:

BLEVE of flammable liquid in horizontal cylindrical tank	
Tank Diameter:	1.8 meters
Tank Length:	1.57 meters
Tank Volume:	4.00 cubic meters
Tank contains liquid	
Internal Storage Temperature:	20° C
Chemical Mass in Tank:	1.88 tons
Tank is 85% full	
Percentage of Tank Mass in Fireball:	100%
Fireball Diameter:	69 meters
Burn Duration:	6 seconds

THREAT ZONE:

Threat Modeled:	Thermal radiation from fireball

DISPERSION CLOUD RESULTS



Red: 165 meters – (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 233 meters – (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 363 meters – (2.0 kW/(sq m) = pain within 60 sec)

Fig. 4 Affected area in the vicinity of the LPG filling station [5]

6. Conclusions

We shall now compare the ALOHA method calculation result with the distances entered to delimit the LPG filling station location; the original distances were:

a) 50 meters between the LPG filling station and the shopping center

b) 10 m meters from the road with normal city traffic and the calculation of the dispersion cloud with the use of ALOHA method:

Red: 58 meters – (21000 ppm = LEL)
Orange: 79 meters – (12600 ppm = 60% LEL = Flame Pockets)
Yellow: 229 meters – (2100 ppm = 60% LEL)

and the result for the BLEVE phenomenon:

Red: 165 meters – (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 233 meters – (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 363 meters – (2.0 kW/(sq m) = pain within 60 sec)

From the above it is possible to come to a definite conclusion that the suggested location of the LPG filling station in Opava is completely **unsuitable** because of the proximity to a densely populated area and the shopping center.

The LPG filling station located as suggested above might be the source of an emergency incident following certain technological break-down causing injuries to a significant number of citizens, including subsequent likely explosion of BLEVE variety.

For the aforementioned reasons involving very high level of risk associated with emergency incidents, it is necessary to make use of feasibility study methods already in the course of assigning the relevant project documentation (e.g. the ALOHA screening method used in the above case study).

It is expected that the procedure set in this manner will lead to a decrease in the level of risks from stationary sources and emergency incidents.

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[4] *Affected area in the vicinity of the LPG filling station, http://www.epa.gov/ceppo/cameo/ aloha.htm*
[5] *Affected area in the vicinity of the LPG filling station, http://www.epa.gov/ceppo/cameo/ aloha.htm.*