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DISPERSION MODELLING FOR RISK ASSESMENT

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Abstract - *In every manufacturing organization, Safety is the prime concern. The paper deals with the safety practices followed in an oil refinery. The management of safety practices are inevitable in any manufacturing sector and so is with the case of a refinery where petroleum products are distilled out. The accidental release of a volatile chemical can present a threat to life and health far from the point of release. The paper deals with quantifying the risk associated in an oil refinery and provide new approach for modelling and simulation of such scenarios with dispersion modelling. Accidental chemical releases are mapped and plotted and the effect on society is further studied. A case scenario is dealt with and it's modelled using ALOHA software. The same is simulated and represented in MARPLOT and GOOGLE EARTH software. The project can be employed in any manufacturing organization involving the production and use of chemicals that pose threat to people and property. The paper thus provides a way to manage safe conditions in every manufacturing sectors involving the use of hazardous chemicals. Also the method can be employed anywhere by anyone.*

***Key Words*: QRA, DISPERSION MODELLING, CAMEO, ALOHA, MARPLOT**

1. INTRODUCTION

Safety is the primary concern in every manufacturing sector. The growing demand for various chemicals landed up in a situation of increasing the production. The multiplication of chemical industries gradually accounts for hazard, risk and vulnerability to population and the environment. The accidental release of volatile chemical proves to be a threat to life and health far from the point of release and can create havoc on the immediate environment depending on the toxicity of the materials involved, terrain features, meteorological conditions and demography.

The paper accounts for quantitatively estimating the risk from a chemical release occurring at a refinery through dispersion modelling. The release scenario is considered and various parameters are studied for modelling the case. The same is then simulated to obtain the actual range of release and is helpful in planning for such emergency conditions.

2. METHODOLOGY

The method adopted for estimating risk quantitatively is dispersion modelling. The risk is assessed for various case studies and suitable one is selected for study. The quantitative estimation is done with the help of modelling and simulating such a case using dispersion modelling. The process is carried out using various software packages like Aloha, Cameo, Marplot and Google map. Firstly, the chemical under the study is considered. In our case we are employing Liquefied Petroleum Gas as the chemical that is being accidently released into the atmosphere. The population analysis is carried out inside as well as in the surrounding areas of the refinery and tabulated. The chemical details are then extracted from the Cameo database which includes all the properties of the chemical under our study. After collection of the chemical details, the meteorological details are taken from Hazmat weather station that has been commissioned at the refinery. Next step is to model a release scenario. This is done with the help of software package called Aloha. The cause of the incident as well as other meteorological details and relevant topographical data is to be fed into the system for creating the model. After successful study of the incident, the parameters like dimensions of the leak, position, etc. are found and fed into the software system. These are evaluated and modelled for suitable scenario. After successful modelling of the case, its then simulated with the help of Marplot software and represented in the location map using Marplot itself or in the Google map. Thus an accidental release of a chemical can be modelled and simulated any conditions arising anywhere using this method. The paper thus deals with a very relevant topic and is of great concern in any manufacturing sector involving the use of chemicals.

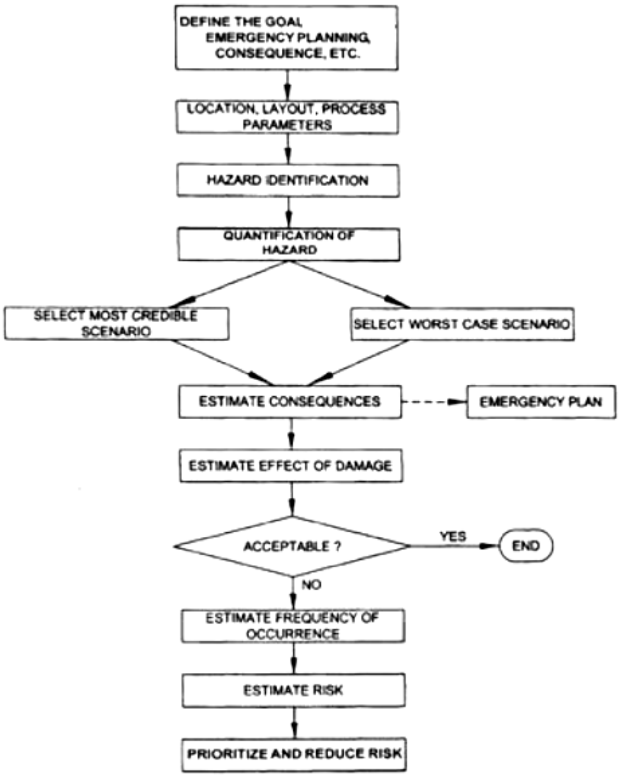


Figure 1. Methodology for risk estimation

3. TOOLS USED FOR MODELLING AND SIMULATION

Various software tools are employed for the modelling and simulation the case scenario. This section deals with detailing about the software packages used in the study. Firstly, Cameo chemical is the chemical database employed for getting all details about the chemical encountered. Then the meteorological details are extracted from Hazmat weather station. The model is created in the software package called Aloha. This model is simulated in Marplot software.

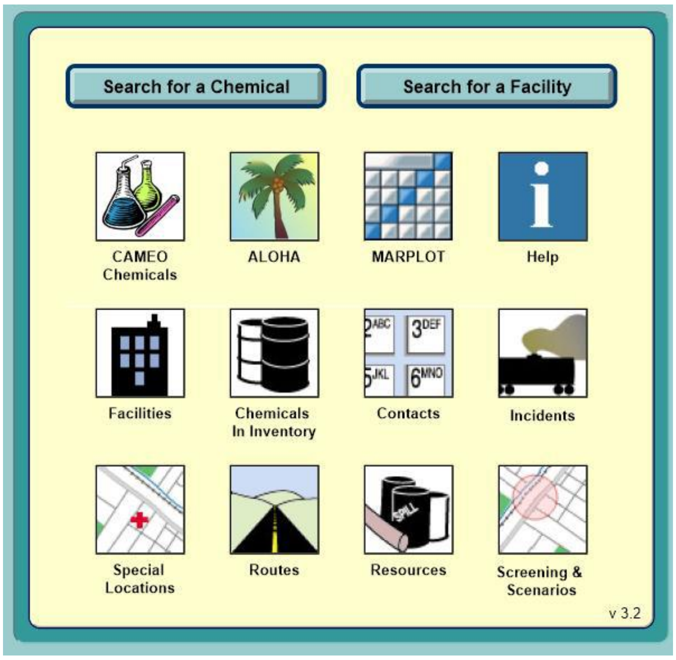


Figure 2. software tools used

3.1 CAMEO software database

Computer Aided Management of Emergency Operations (CAMEO) software package is used in our study. It is a system of software applications used to plan for and respond to chemical emergencies. Developed by EPA and the National Oceanic and Atmospheric Administration to assist front-line chemical emergency planners and responders, CAMEO can access, store, and evaluate information critical for developing emergency plans. CAMEO Chemicals has an extensive chemical database with critical response information for thousands of chemicals. There are two primary types of datasheets in the database: chemical datasheets and UN/NA datasheets. Chemical datasheets provide physical properties, health hazards, information about air and water hazards, and recommendations for firefighting, first aid, and spill response. UN/NA datasheets provide response information from the Emergency Response Guidebook and shipping information from the Hazardous Materials Table.

3.1 ALOHA modelling software

The Areal Locations of Hazardous Atmospheres (ALOHA) software is used for modelling the case study. ALOHA is an atmospheric dispersion model used for evaluating releases of hazardous chemical vapors. ALOHA allows the user to estimate the downwind dispersion of a chemical cloud based on the toxicological/ physical characteristics of the released chemical, atmospheric conditions, and specific circumstances of the release. ALOHA can estimate threat zones associated with several types of hazardous chemical releases, including toxic gas clouds, fires, and explosions. These models can then be represented or simulated in the area under consideration.

Hazard categories modeled in ALOHA.

Scenario\Source	*Direct source*	*Tank*	*Puddle*	*Gas Pipeline*
Vapor cloud	Toxic vapors	Toxic vapors	Toxic vapors	Toxic vapors
Vapor cloud (flash fire)	Flammable area	Flammable area	Flammable area	Flammable area
Vapor cloud (explosion)	Overpressure	Overpressure	Overpressure	Overpressure
Pool fire	NA	Thermal radiation	Thermal radiation	NA
BLEVE (fireball)	NA	Thermal radiation	NA	NA
Jet fire	NA	Thermal radiation	NA	Thermal radiation

Figure 3. Hazards modelling in ALOHA package

3.3 MARPLOT simulation software

Mapping Application for Response, Planning, and Local Operational Tasks (MARPLOT) is the software employed for simulating the model obtained in ALOHA package. The program comes with several global background basemap options, with maps in both street and satellite view. Users can add to the information shown on the map by drawing their own objects such as chemical facilities, schools, or response assets or by importing layers of objects already created by other sources.

4. CASE STUDY

The case study is done in the Bharat Petroleum Corporation Limited – Kochin Refinery Limited, located at Ambalamugal, Eranamkulam. The case is modelled as a release scenario of LPG from a storage location. The same is modelled and simulated.

4.1 Location details:

To get a better understanding for creation of the dispersion model, we must take into account the approximate position of the LPG sphere storage site. This is done with the help of Latitude and Longitude coordinates along with the altitude of the area under our concern and the elevation of the location. As per the details, the value of latitude and longitude for the considered area is:

Location: 9.970991°N, 76.379862°E (Latitude and Longitude)

Elevation: *0 cm*

4.2 Population analysis

The population analysis is carried out for estimating quantitatively, about a risk scenario. It is carried out in the vicinity of BPCL – KRL as well as inside the refinery. The values are tabulated and these values will be further used to estimate the societal risk diagram in correlation with the dispersion modelling scenario. This will thereby result in risk estimation quantitatively.

Table 1. Popolation analysis surrounding BPCL

LOCATION	POPULATION
Govt. High school , Kuzhikkad	423
Kochi refinery school	1350
Housing colony	1656
Retail outlet	7
Ambalamugal commercial area	600
Peripheral area - new units	300

4.3 Meteorological Input

Various data is then extracted from the weather station regarding the climatological conditions prevailing and a best scenario is chosen to model the case study. In this project, the time chosen for the incident is March 12, 2016 at 10:10 IST. The meteorological data from hazmat weather station is given in Table 3.

Table 2. Population analysis inside BPCL

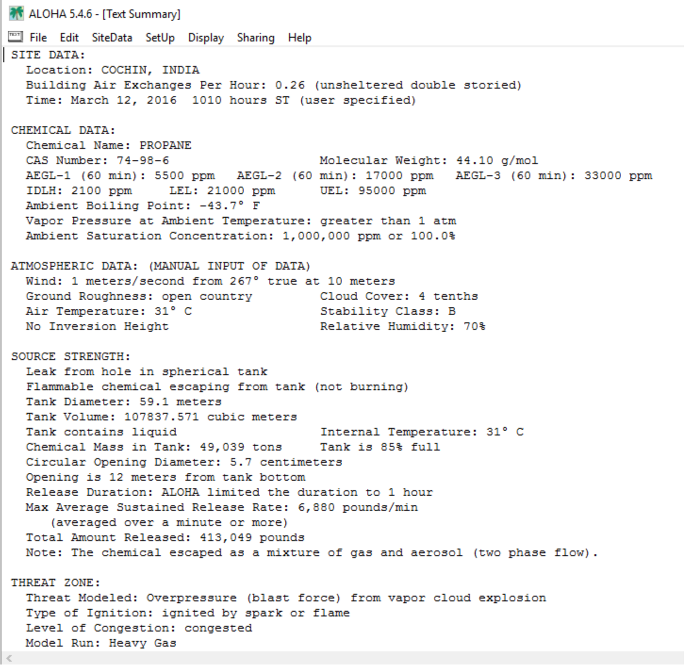
NO:	LOCATION	POPULATION
1	Project stores	2
2	BPCL marketing office	30
3	CDU/VDU-II	44
4	CDU - II substation	2
5	CDU- II / ARU DIDC	9
6	CDU - II Maintenance	10
7	Tank farm office	10
8	LPG control room	4
9	POL truck loading	4
10	POL Wagon loading	11
11	FCC Unit area	22
12	CDU - I area	14
13	Administration building	457
14	Main fire station	14
15	project warehouse	10
16	PIBU/PRU	6
17	LPG Bottling plant	22
18	ACTP/APTP	5
19	Utility control room	2
20	Central QC room	15
21	DHDS control room	9
22	DHDS unit	3
23	UB 8/9,HPN plant	8
24	DHDS substation	8
25	ARU/SWS & SRU	5
26	DHDS ETP	3
27	Main laboratory/R&D	10
28	Maintenance shop	209
29	CPP/UB-10/GTG	15
30	ETP II & III	5
31	ETP IV	2
32	DHDS fire station	7
33	NHT CCR	4
34	CGO HDS	4
35	SRU block	3

Table 3. Meteorological data from Hazmat weather station during the time of incident

Time	Temp	Dew point	H	Wind direction	Wind speed	Peak wind speed
10:07	33	26	69	231	0.1	0.1
10:08	33	26	69	210	0.1	0.2
10:09	33	26	68	184	0.1	0.2
10:10	33	26	69	238	0.1	0.1
10:11	33	26	69	213	0.1	0.2
10:12	33	26	69	221	0.1	0.2
10:13	33	26	69	203	0	0.1
10:14	33	26	69	218	0.1	0.2
10:15	32	26	69	197	0.1	0.1
10:16	32	26	69	216	0.1	0.3
10:17	32	26	70	214	0.1	0.1
10:18	32	26	69	218	0.1	0.2
10:19	32	26	70	248	0.1	0.2
10:20	32	26	70	281	0.1	0.1
10:21	32	26	69	241	0.1	0.2
10:22	32	26	70	204	0.1	0.1
10:23	32	26	70	264	0.1	0.2
10:24	32	26	70	301	0.1	0.4
10:25	32	26	70	212	0.2	0.2
10:26	32	26	70	225	0.1	0.3
10:27	32	26	71	241	0.2	0.3

4.4 ALOHA Modelling

All the required data are then fed into ALOHA system for creation of the model. The system generates various case scenarios considering all the parameters inputted. The models are then simulated to obtain various threat zones depending upon the case considered.



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ALOHA 5.4.6 - [Text Summary]
File Edit SiteData SetUp Display Sharing Help
SITE DATA:
  Location: COCHIN, INDIA
  Building Air Exchanges Per Hour: 0.26 (unsheltered double storied)
  Time: March 12, 2016  1010 hours ST (user specified)

CHEMICAL DATA:
  Chemical Name: PROPANE
  CAS Number: 74-98-6                   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: -43.7° F
  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: 1 meters/second from 267° true at 10 meters
  Ground Roughness: open country        Cloud Cover: 4 tenths
  Air Temperature: 31° C                Stability Class: B
  No Inversion Height                   Relative Humidity: 70%

SOURCE STRENGTH:
  Leak from hole in spherical tank
  Flammable chemical escaping from tank (not burning)
  Tank Diameter: 59.1 meters
  Tank Volume: 107837.571 cubic meters
  Tank contains liquid                  Internal Temperature: 31° C
  Chemical Mass in Tank: 49,039 tons    Tank is 85% full
  Circular Opening Diameter: 5.7 centimeters
  Opening is 12 meters from tank bottom
  Release Duration: ALOHA limited the duration to 1 hour
  Max Average Sustained Release Rate: 6,880 pounds/min
     (averaged over a minute or more)
  Total Amount Released: 413,049 pounds
  Note: The chemical escaped as a mixture of gas and aerosol (two phase flow).

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by spark or flame
  Level of Congestion: congested
  Model Run: Heavy Gas
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Figure 4. ALOHA Modelling Text summary

The flammable threat zone, Overpressure threat zone and Toxic threat zones are modelled using the ALOHA software package and is represented as shown in figures 5,6 and 7. The same is then simulated and represented in the map using MARPLOT software as shown in figures 8, 9 and 10.

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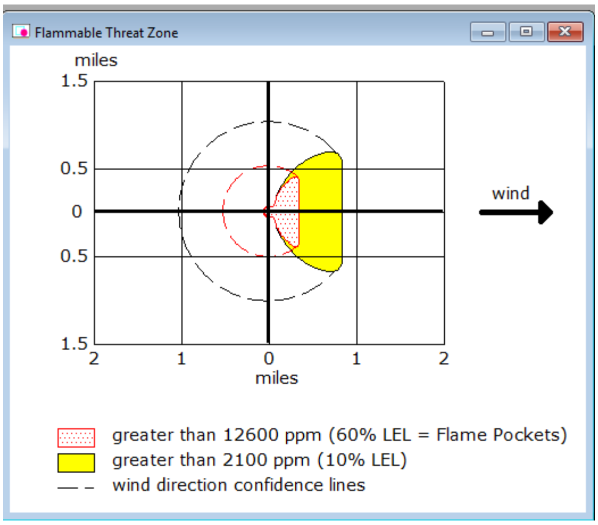

Figure 5. Flammable threat zone

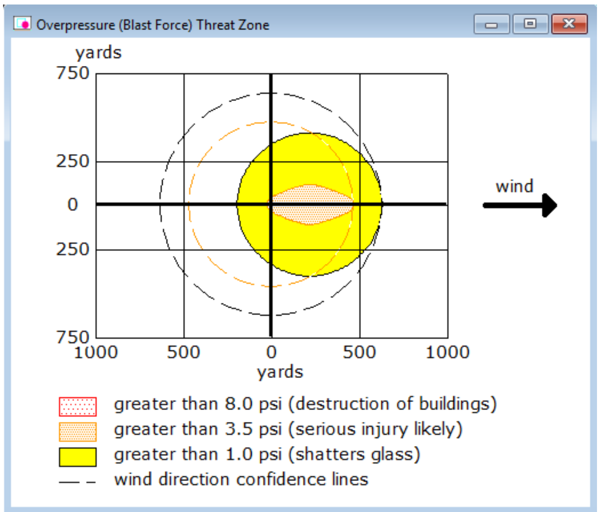

Figure 6. Overpressure threat zone

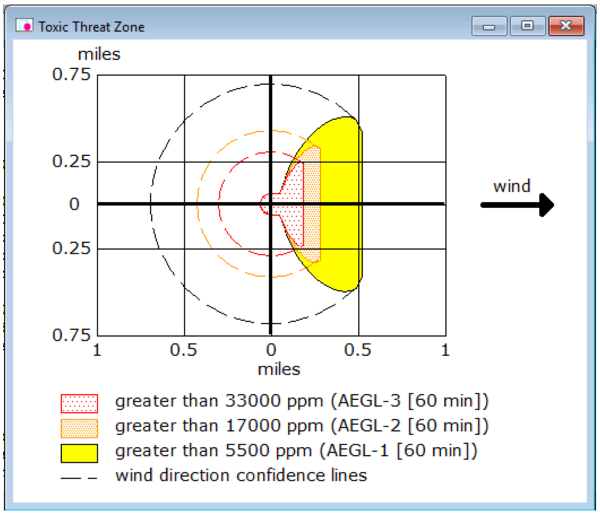

Figure 7. Toxic threat zone

4.5 Representation of the Model & Simulation

The modelled case is then simulated using MARPLOT software to obtain a more detailed overview of the case under concern.

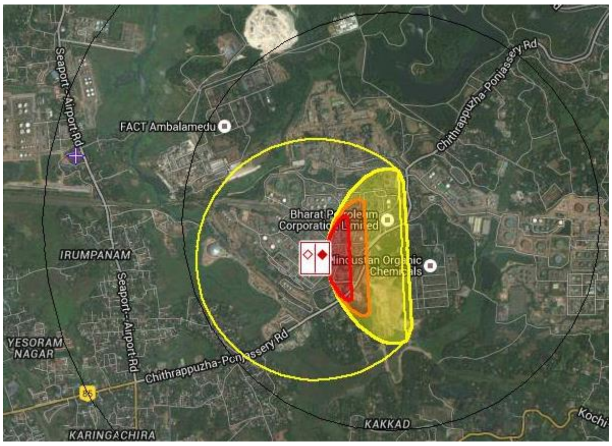

Figure 8. Representation of Toxic threat zone

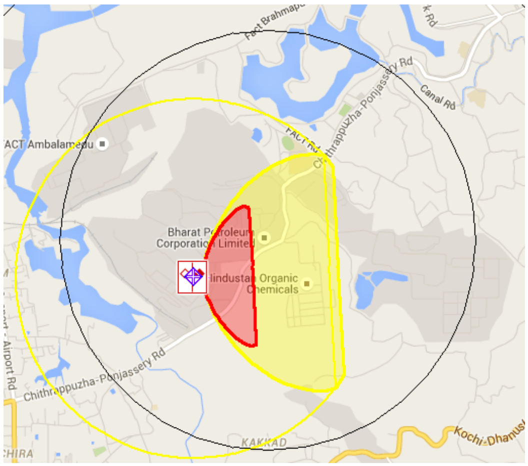

Figure 9. Representation of Flammable threat zone

Figure 10. Representation of BLEVE threat zone

5. CONCLUSIONS

The paper discuss about a case study of chemical release scenario in BPCL refinery. The paper considers population analysis inside as well as surrounding of the refinery for quantitatively estimating the risk. Also the dispersion modelling is developed with the help of various software packages to represent the simulated model for the case study. The QRA is estimated with the help of population analysis and dispersion modelling as discussed above. The developing a process plan that would be helpful for emergency response and restoration team during an unexpected incident. Also, this will prove to be helpful in determining the rate and direction of chemical release as well as the emergency plan required in order to suppress any chances of danger. These modeling can be employed in any case where there is a chemical release and thus proves to be highly relevant and useful to prevent undesired events owing to loss of life and properties. This can be employed anytime anywhere.

6. REFERENCE

1. Risk Management - Risk assessment techniques - International Standard IEC/ISO 31010, 2011.
2. Renjith V R, Consequence modeling, Vulnerability assessment, and fuzzy fault tree analysis of Hazardous storage in an industrial area", Ph. D thesis, Division of safety and fire Engineering, School of Engineering, CUSAT, page 106.
3. Schnelle, Karl B. and Dey, Partha R. (1999).Atmospheric Dispersion Modeling Compliance Guide (1st ed.). McGraw-Hill Professional. ISBN 0-07-058059-6.
4. Risk Management - Risk assessment techniques - International Standard IEC/ISO 31010,2011.
5. U.S. Environmental protection Agency, ALOHA user's manual 2007.
6. VISHNU V, Air Dispersion Modeling for Emergency Response and Restoration, International Journal of Latest Engineering and Management Research (IJLEMR) ISSN: 2455-4847, Volume 1 Issue 5 ǁ JUNE 2016 ǁ PP 01-07.