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Consequence Analysis on Hazardous Locations

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Abstract: Fuel can be defined as the material which produces energy on combustion. Fuel is the most important source that lead whole world to extract energy in different forms, on that case we need to store the fuel for seamless production of energy. On contrary, the fuels which are energy producer are hazardous too. The proper safety measures should be taken in order to safeguard assets and life of the people. The study of fire nature of hydrocarbon fuel is most important factor to provide the safety measures. The fuel which using for vehicle engine like petrol which stored in pool can exposed to fire inducers that may cause pool fire phenomena. In this project the phenomena of BLEVE, Vapor cloud explosion, Pool fire model and its characteristic factors would be calculated. Tata motors Pantnagar plant use petrol to fuel the vehicles for testing and staff bus. In Pantnagar plant around 10,000 workers are working in all shifts, if fire on fuel storage yard may cause heavy destruction. The main objective of the project is to find the source of fire, and by considering worst case scenario calculating the amount of thermal radiation by means of variables like pool size, flame temperature, surface emitted power etc., and the distance of affection due to fire is estimated and shown using ALOHA software.

I. INTRODUCTION

TATA GROUP

Tata group is an Indian multinational conglomerate headquartered in Mumbai, Maharashtra, India. It is one of the largest conglomerates in India by market capitalization and revenue. It encompasses several primary business sectors: chemicals, consumer products, energy, engineering, information systems, materials, and services. Tata Group has operations in more than 80 countries across six continents and its companies export products and services to 80 nations .It comprises 114 companies and subsidiaries in eight business sectors.

Tata Motors Limited is India's largest automobile company, with revenues of Rs. 35651.48 crores (USD 8.8 billion) in 2007-08. It is the leader in commercial vehicles in each segment, and among the top three in passenger vehicles with winning products in the compact, midsize car and utility vehicle segments. The company is the world's fourth largest truck manufacturer, and the world's second largest bus manufacturer. The company's 23,000 employees are guided by the vision to be "best in the manner in which we operate best in the products we deliver and best in our value system and ethics." ***Established in 1945***, Tata Motors' presence indeed cuts across the length and breadth of India. Over 4 million Tata vehicles ply on Indian roads, since the first rolled out in 1954. The company's manufacturing base in India is spread across ***Jamshedpur (Jharkhand),Pune (Maharashtra), Lucknow (Uttar Pradesh) Sanand (Gujarat) and Pantnagar(Uttarakhand).***

The plant began commercial production in August 2007. This is the company's fourth plant, after Jamshedpur (commercial vehicles), Pune (commercial vehicles and passenger vehicles) and Lucknow (commercial vehicles). The plant is spread over 975 acres, of which 337 acres is occupied by the vendor park. State-of-the-art facilities include weld shops, paint shops, engine and gear box shops and assembly lines. The company has invested over Rs.1000 cr. in the plant. Vendors for the vehicle have made additional investments to set up their plants in the vendor park adjoining the plant.

II. NEED FOR THE STUDY

The study of fire nature of hydrocarbon fuel is most important factor to provide the safety measures. The fuel which using for vehicle engine like petrol which stored in pool can exposed to fire inducers that may cause pool fire phenomena. In this project the phenomena of BLEVE, Vapour cloud explosion, Pool fire and its characteristic factor would be calculated. Tata motors pantnagar plant use petrol to fuel the vehicles for testing and staff buses. In pantnagar plant around 10,000 workers are working in all shifts, if fire on fuel storage yard takes place it may cause heavy destruction by both life of workers and assets of company. So, the study of fire in storage yard is essential in this case.

III. OBJECTIVE OF THE STUDY

The main objectives of the project are

- To calculate the thermal radiation, fire duration due to BLEVE at propane yard.
- To calculate the overpressure due to vapour cloud explosion at CNG yard.
- To calculate thermal radiation, pool diameter due to pool fire at diesel yard.

IV. RELATED WORK

Fuels are mostly hazardous in nature and flammable at point of source. The study of particular fuel will help us to know the fire nature and effective method of precaution to reduce accident.

The consequence analysis used to calculate the risk associated in systematic pattern of risk assessment. Fire and explosion modeling of listed hazardous locations and their risk level are needed to be calculated.

SCENARIO SELECTION FOR CONSEQUENCE ANALYSIS

The scenario is the events that result in an accident. The postulation of scenarios is carried out based on the results obtained from hazard identification studies. Possible failures or loss of containment scenarios are Instantaneous, release due to catastrophic failure of tanks**,**Continuous release at significant rates for long durations from tanks and vessels caused by major damage or rupture of connected pipe work etc.

BOILING LIQUID EXPANDING VAPOUR EXPLOSION (BLEVE)

BLEVE stands for Boiling Liquid Expanding Vapour Explosion. It occurs when vessel containing superheated liquid (e.g. Propane) catastrophically fails usually as a result of external exposure. The fire pressurizes vessel causing the relief valve to open which allows pressurized vapour to escape. Therefore wall get weaken it leads tank to burst.

VAPOUR CLOUD EXPLOSION

The vapour cloud explosion begins with a release of quantity of flammable vaporizing liquid or gas from storage tank (e.g. CNG).

DEFLAGRATION

The mechanism for the propagation of an explosion reaction through a flammable gas mixture that is thermal in nature. The velocity of the reaction is always less than the speed of sound in the mixture but is capable of causing damage. A deflagration is possible if a gases concentration rises above its lower flammability limit (LFL).It occurs when burning velocity relatively slow, usually at approximately 1 m/s.

DETONATION

The propagation of a combustion zone at a velocity that is greater than the speed of sound in the un-reacted medium. It occurs when flame speed is very high approximately 2500 m/s. Deflagration on long hollow pipe can result to detonation by means of turbulence.

POOL FIRE

Pool fires begin with the release of a flammable material from process equipment or storage. If the material is liquid, stored at a temperature below its normal boiling point, the liquid will collect in a pool. The geometry of the pool will be dictated by the surroundings.

V. PROPOSED SYSTEM

FIRE AND EXPLOSION MODELING

These models are used only when the material released is flammable and the vapour cloud concentration is within the flammable range. The various types of the fire and explosion models are

The hazardous locations which we have taken into study are propane, CNG and Dieselstorage yard.

The model which we are using for ***propane yard is BLEVE modeling, CNG yard is vapour cloud explosion and diesel yard is pool fire modeling.***

BLEVE (Fireball)

A fireball is a intense spherical fire resulting from a sudden release or pressurized liquid or gas which is immediately ignited, burning as it expands, forming a ball fire, rising in the air. The fireball is assumed to be constant over this duration, although in reality some growth and decay would occur.

TNT EQUIVALENT METHOD

The Vapour Cloud Explosions begin with a release of a large quantity of flammable vaporizing liquid or gas from a storage tank, transport vessel or pipeline producing a dangerous overpressure. These explosions follow a well-determined pattern. There are basically four features which must be present for an effective vapour cloud explosion to occur with an effective blast. In general conventional TNT equivalent method to be used, the blast parameters and characteristics are compared with the explosion of considered material. Vapour cloud's explosive power is proportionally related to the total quantity of fuel present in the cloud.

Steps in vapour cloud explosion

1. Find flash fraction of the fuel

2. Weight of the fuel in cloud

3. TNT equivalent weight

1. **Flash fraction of fuel**

fl=1-exp[-c p*dt/Lh]

2. Weight of the fuel in cloud

Wf=Q*Fl

3. Equivalent weight of TNT (kg)cm2

WTNT=αe*wf*Hf/HTNT

POOL FIRE

Pool fire is a turbulent diffusion fire burning above an upward facing horizontal of vaporizing liquid fuel (usually symmetrical) under conditions where the fuel vapor or gas has zero or very low initial momentum.

Steps in pool fire model

1. Find pool fire diameter

2. Find pool fire duration

3. Find flame height

1. Pool fire diameter

Adike = πD2/4

2. Pool fire duration

Tb = 4V / πD2n

3. Pool fire flame height

Hf = 42 D (m"/ra√(g D))0.61

VI. PERFORMANCE EVALUATIONS

LOCATION DETAILS

Hazardous Location – 1

Propane Yard

As part of utilities Tata motors pantnagar plant has propane for its paint shop and the canteen. It has propane with 4 tanks of 240 m3 capacity each. There is a provision to add another tank of the same size at a future date.

Hazardous Location – 2

CNG YARD

As part of utilities Tata motors pantnagar plant has CNG for its engine shop and the TCF shop. It has CNG with 3 cascades of 9000 liters of capacity all together.

Hazardous Location – 3 ***High Speed Diesel Yard***

As part of utilities Tata motors pantnagar plant has Diesel for its engine shop and the TCF shop. It has Diesel with 3 Tanks of 50 kilolitres capacity each.

CALCULATION MANUAL

1 Propane Yard

DATA

Vessel data:

Volume of the bullet = 240 m3

Maximum fill limit = 85% of water capacity

Specific gravity = 0.51 kg/m3

Mass of fuel = 100000 kg

Model: BLEVE

Steps in risk analysis of propane tank is as follows

1. Calculate the maximum fireball diameter

2. Calculate the fireball combustion duration

3. Find the height of the fire ball

4. Initial ground level of the hemisphere

5. Finding the view factor

1. Maximum diameter of the fire ball (Dmax)

Dmax=5.8M 1/3

Dmax=269.21m

2. Fireball Combustion Duration

TBLEVE = 2.6M 1/6

TBLEVE=17.706s

3. Centre Height Of The Fireball

HBLEVE=0.75dmax

HBLEVE = 201.15m

4. Initial Ground Level Hemisphere Diameter

Dinitial = 1.3dmax

Dinitial = 348.673m

5. View Factor

F21=L(Dmax/2)2/(L2+H2

BLEVE)3/2

F21=0.0780

CNG YARD

Vessel Data

Volume of the cylinder = 75 litres

Mass of the fuel = 12 kg

Octane number = 120

Physical characteristics

Specific gravity = 0.55 kg/m3

Boiling point = -161.5ºc

Atmospheric temperature = 45°c

MODEL: VAPOUR CLOUD EXPLOSION (TNT equivalent method)

Steps in vapour cloud explosion

1. Find flash fraction of the fuel

2. Weight of the fuel in cloud

3. TNT equivalent weight

1. **Flash fraction of fuel**

fl=1-exp[-cp*dt/Lh]

Fl=0.8934

2. Weight of the fuel in cloud

Wf=Q*Fl

Wf=10.71 kg

3. Equivalent weight of TNT(kg)cm2

WTNT=αe*wf*Hf/HTNT

WTNT=0.3192 kg

DIESEL YARD

Vessel data:

Volume of the tank = 50 m3

Maximum fill limit = 85% of water capacity

Specific gravity = 0.81 kg/m3

Physical characteristics:

Nature : flammable

Boiling point = 170°c

Atmospheric temperature = 45°c

Heat of combustion = 43500 kj/kg.k

MODEL: POOL FIRE MODEL

Steps in pool fire model

1. Find pool fire diameter

2. Find pool fire duration

3. Find flame height

1. Pool fire diameter

Adike = πD2/4

D = 5.047 m

2. Pool fire duration

Tb = 4V / πD2n

Tb= 51000 sec

3. Pool fire flame height

Hf = 42 D (m"/ra√(g D))0.61

Hf = 8.77 m

CALCULATION – SOFTWARE

Modeling Scenario Using Software

Details of software

Name: ALOHA (**A**rea **Lo**cations **H**azardous **A**tmosphere)

Version: 5.4.1.2

Developed by: Environment Protection Agency and National Oceanic and Atmospheric

Administration

Description***:***

ALOHA (Areal Locations of Hazardous Atmospheres) is a computer program designed especially for use by people responding to chemical releases, as well as for emergency planning and training. ALOHA models key hazards—toxicity, flammability, *thermalradiation* (heat), and *overpressure* (explosion blast force)—related to chemical releases that result in toxic gas dispersions, fires, and/or explosions. (**Note:** Inversions prior to 5.4, ALOHA only models the toxic threat: specifically, how a toxic gas cloud might disperse in the atmosphere after an accidental chemical release.)

Models used:

Propane Yard – BLEVE

CNG Yard- Vapour Cloud Explosion

HSD yard – Pool Fire

Data required

Site data

Name of the place: Pantnagar, Uttarakhand, India

Elevation: 233 m

Latitude: 28º58’

Longitude: 79º34’

Humidity: Medium

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Wind speed: 3.1 m/s

Cloud cover: clear

Roughness: open country

Temperature: 45ºc

Propane Yard

Liquid level: 85 %

Diameter of the tank: 3.86 m

Length of the tank: 20.468 m

Volume: 204 m3

CNG Yard

Diameter of the cylinder: 0.2405 m

Length of the cylinder: 1.651 m

Volume: 0.075m3

HSD Yard

Diameter of the tank = 4.6 m

Length of the tank = 3.01 m

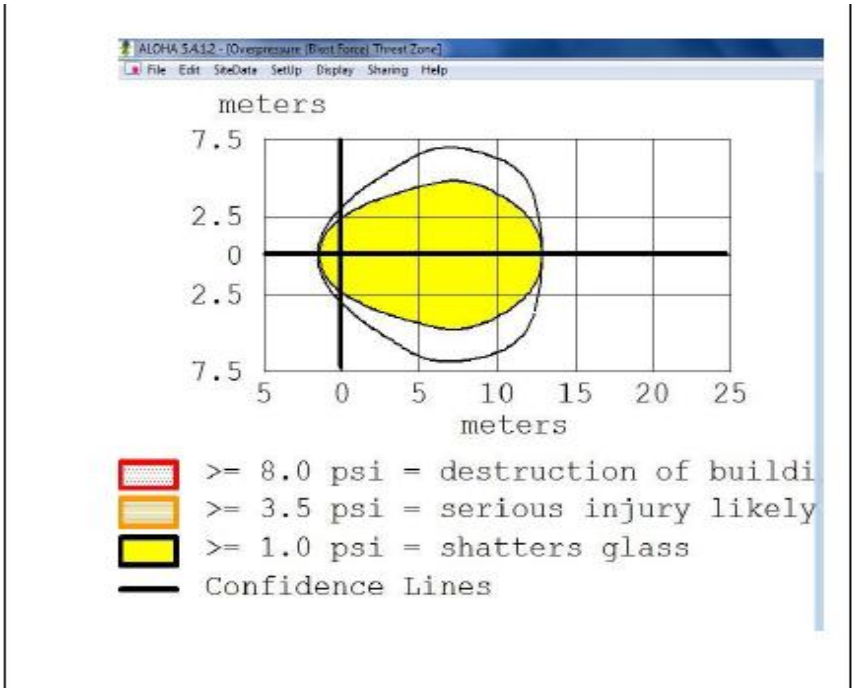
Volume = 50.03 m3

Description of analysis:

Propane tank volume of 240 m3 of mass 100 MT is taken into consideration. Basic condition is to model BLEVE loss of containment of full mass inside the tank. Therefore, here the total mass of 100 MT is lead to explosion.

Analysis

Values calculated manually and calculated using software is near or same



VII. CONCLUSION

From this study, we are able to predict the consequence of the accident and effect of that explosion in human life and the physical assets The hazardous locations propane, CNG, Diesel storage yard are taken into account and the further consequence analysis by both manual and software calculation using ALOHA software are resulting the associated risk and the distance that explosion will effect. Here in this study the single tank or vessels are taken into consider and their explosion effects on other tanks or cylinder are well explained using the domino theory or cascading effect. Therefore, here to conclude that • In BLEVE model of propane maximum intensity of radiation calculated and distance affected was modeled in ALOHA version 5.4.1.2 software. • In Vapour Cloud Explosion model of CNG yard overpressure is calculated and distance affected was modeled using ALOHA version 5.4.1.2 software.

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