Fire & Explosion Prevention Strategy in Refineries

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***Abstract*— In current civilizations hydrocarbon are a primary source. Oil refineries are one way hydrocarbons are processed for use crude oil is processed in several stages to form desired hydrocarbons used as fuel & in other products. Hydrocarbon is useful as well as harmful if it is not treated properly and become the cause of fire & explosion. The main objectives of the paper to give a systematic approach to reduce the fire & explosion hazard in refinery. The prevention measures are to avoid any fire or explosion risks by eliminating either the potential ignition sources or both. Job Safety Analysis is the method we are applying for the fire prevention in refineries. In this we find Likelihood of occurrence, potential severity of harm by which we identify the level of risk and the prevention take place. This strategy will save the refinery's material as well as its property and mainly safe the lives of peoples.**

Keywords—Fire & Explosion; LPG bullet; BLEVE; Classification of petroleum products; Job safety analysis; Thermal Radiation etc.

I.INTRODUCTION

Fire is a process in which substances combine chemically with oxygen from the air & typically give out bright light, heat & smoke. Explosion is a sudden release of mechanical, chemical, or nuclear energy is a sudden & often violent manner with the generation of high temperature & usually with the release of gases. Refinery is a production facility composed of a group of chemical engineering unit processes & unit operations refining certain materials or converting raw materials into products of value. Refinery is the highly risk prone area where the workplace hazard is occurred due to a minor mistake or irregularity and this mistake easily take a form of fire and explosion which cause a dangerous hazard. Fire & Explosion is a hazard if it occurs once then it cannot stop easily as it spread within a short period of time with the help of medium, so for the prevention of these hazard we are applying job safety analysis by which we can easily identify the risk and once risk is identify then it easy to prevent the hazard.

Some norms & laws which are applicable to petroleum industry like:

- The Factories Act, 1948 with The Madhya Pradesh /Chhattisgarh factories Rules, 1962, schedule viii Rule 107 prescribed under section 87.
- The Gas Cylinders Rules, 2004 chapter II General Provisions.
- The Gas Cylinders Rules, 2004 with the Static and Mobile Pressure Vessels (Unfired) Rules, 1981.
- The Petroleum Act 1934, Rules 1976
- The Explosive Act 1884, Rules 2008
- MSHIC Rules 1989
- OISD Standard
- ISO Standard
- CIMAH Regulations 1996
- OSHA 1970
- The motors transport workers Act 1961
- The Manufacture storage and import of hazardous chemical Rules 2000

Classification of petroleum products on basis of flash points-

Class 0 – Liquefied petroleum gases.

Class 1 – Liquids which has flash points below 21°c.

Class 2 – Liquids flash point from 21°c up to 55°c.

Class 3 – Liquids flash point above 55°c up to 100°c.

Unclassified – Liquids which have flash points above 100°c.

II. PROPOSED METHODOLOGY

Job safety analysis (JSA) –

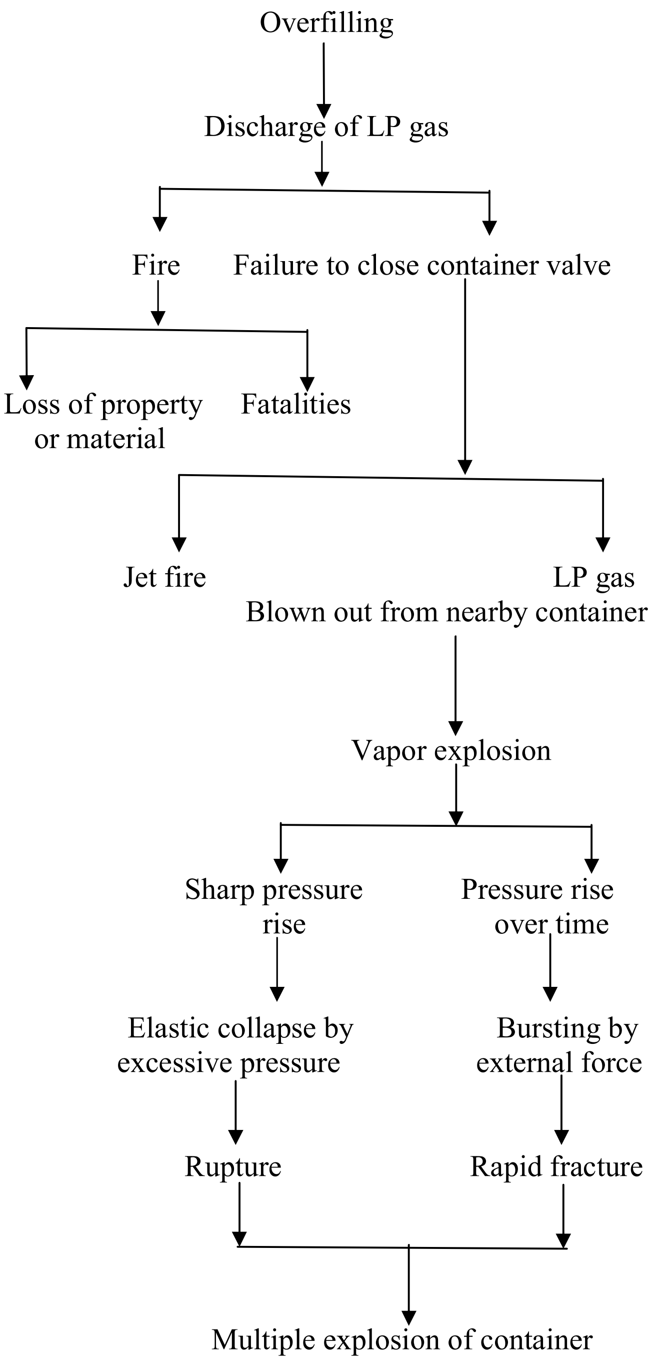
Job safety analysis is one of the risk assessment tools used to identify & control workplace hazards. A job safety analysis is a second ties risk assessment with the aim of preventing personal injury to a person, or their colleagues & any other person passing or working adjacent, above or below. A workplace hazard is defined as 'anything that has the potential to injure or harm'. Risk is the correlation between likelihood and consequence. Job safety analysis is an accident prevention technique that is used to find the potential hazard associated to the job and give the control measures to minimize the hazards. A job safety analysis can do much toward reducing accidents & incidents in the workplace but it is only effective if it is reviewed & updated periodically, even if no changes have been made in a job hazard that were missed in an earlier analysis could be detected. If an illness or injury occurs on a specific job, the job safety analysis should be reviewed immediately to determine whether changes are needed in the job procedure if a close call or a near miss has resulted from an employee equal to failure to follow job procedure, this should be discussed with all employees performing the job.

Risk Level:-
- Low risk
- Medium risk
- Significant risk
- High risk

Job related fatal event, injuries and fatalities creates daily at the workplace. These occurring of unwanted event on the improper job procedure and on the untrained people. According to the job safety analysis method have reduced some improper job procedure and control the hazard activity of workplace. According to the job safety analysis method have some important facts and recording and selection of the job then identifying the potential hazard process and so on. JSA methodology using for the improve productivity and JSA have 4 basic step wise work which are-
- Selection of jobs to be analyzing
- Breaking the job down into steps
- Identification of potential hazards in process
- Determine preventive measure and control to overcome this problems.

The basic purpose of JSA is to identify workplace hazards with a "likelihood" of possible or greater, identifying problems and break the job, and then also control the main issues. The outcome of an event expressed in consequences of qualititatively or quantitatively a loss injury, disadvantage or gain.

Block diagram of LPG overfilling



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ANNEXURE-I

JOB SAFETY ANALYSIS WORKSHEET
WORK AREA …………

Company name:…………
Site name:……………….
Unit in charge:..………….

Date:……………….
Permit to work:…….
Approved by:……..

Sr. No.	Work	Potential Hazards	Recommendation

JOB SAFETY ANALYSIS WORKSHEET: WORK AREA - LPG BULLET

S.NO.	WORK	POTENTIAL HAZARDS	RECOMMENDATION
1.	Overloading	Spillage and pipe bursting.	Loading of bullet is up to limit with proper attention
2.	During stored	Crack & rupture	Proper inspection and measurement.
3.	During unloading	Back flow and incident occur.	Proper training to employees and use proper PPEs.
4.	During supply	Static electricity generated, leakage, leak & line rupture.	Ground ignitable hazardous waste to prevent spark.
5.	over pressurization	It leads to a violent rupture of the container.	Proper monitoring.
6.	Operational error	Delay of process, loss of time and material used.	Use of PPEs and proper inspection required.
7.	Failure of bullet	Risk of unconfined external fire or high risk of explosion.	By maintain its proper safety valve.
8.	Bullet is not air tight	Uncontrolled vapors release to ambient or risk of confined external fire.	It can be control by proper design of bullet.
9.	Over temperature	BLEVE, fracture, rupture, boil over.	Provided proper cooling medium.
10.	Bursting of storage tank	Causing shock wave, heat wave, sound wave & shooting out of fragments.	By monitoring temperature and pressure.

III. SAMPLE CALCULATION OF EXPLOSION

The calculation of explosion storage LPG tank capacity of 56 gallon which is liquefied under the pressure and has above ground storage at ambient temperature has the following details.

Total capacity = 56 gallon
Design Temperature = -42 to 55°C,
Design Pressure = 20 kg/cm2 or 1.96 mpa
Density of LPG = 0.52
Normal Working Pressure = 15 Kg/cm²,
Tank = Bullets,
Maximum Filling ratio = 80%,
Maximum Ambient Temperature = 45°C.
Heat of combustion of LPG (H_c)= 46000kj/kg

Capacity of tank= 56 gallon

Convert gallon into kg;

1 us gallon =3.78 L

56×3.78= 211.682 L

Density of LPG = 0.52

211.68×0.52=110.073=110kg (Approx)

Calculation for intensity of radiation:

1. $t_d = 0.9m^{1/4}$

   t_d = Duration of combination

   $= 0.9(110)^{1/4} = 2.84$ sec

2. $D_{max} = 5.8m^{1/3}$

   D_{max} = Diameter of fireball

   $= 5.8(110)^{1/3}$

   =2.735 m

3. $H_{FB,}$ Height of fire wall = $0.75\times D_{max}$

   = 0.75×27.35

   = 20.51 m

4. Thermal radiation from fire ball or Maximum emitted thermal flux =

   $E_{max} = 0.133\times f\times H_c\times MF_B^{1/2}$

   Where: - f, Radiant heat fraction = $0.27\, P_B^{0.32}$

   As normal bursting pressure is $15kg/cm^2$ and maximum bursting pressure are $20\ kg/cm^2$ so we are taking maximum bursting pressure for calculation, so that we can identify the maximum limit of bullet.

   Hence $P_B = 20\ kg/cm^2$ or 1.96 mp_a

   (Assume)

   $f= 0.27(1.96)^{0.32}$

   $f= 0.27 \times 1.240$

   f=0.33(Radiant heat fraction)

   $E_{max} = 0.0133\times0.33\times46000\times(110)^{1/2}$

   $=298.6kw/m^2$

5. Radiation received by a target at a distance of 10 m (assumed):

   I, Intensity of radiation is expressed as

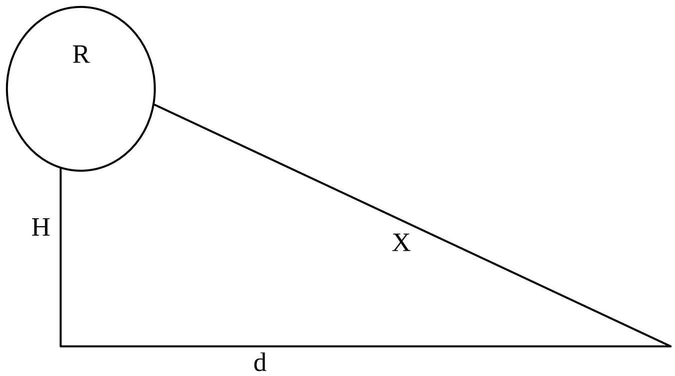
   = Ʈ ×f× Ep

   $P_{w:}$ Partial pressure of water vapors

   $Ʈ= 2.02(P_w \times X)^{-0.09}$

   $=2.02(4035.79.147)^{-0.09}$

   =0.783 atmospheric transmissivity (Dimensional less)



$X= \sqrt{H^2+d^2} - R$

$= \sqrt{(20.51)^2+(10)^2}$ -13.67

= 9.147 m

F, View factor= $D^2/4(r + x)^2$

$= (27.35)^2 / 4(13.67+9.147)^2$

=748.022/2082.461

= 0.35(View factor)

Ep, Emissive power= $Ƞ\times M\times H_c/\pi\times D^2\times t$

$= 0.25\times110\times46000/\pi(27.35)^2\times2.84$

$= 189.63 kw/m^2$

$I = \tau \times f \times Ep$

$= 0.783 \times 0.35 \times 189.63$

$= 51.97 kw/m^2$ to target at 10m distance.

The intensity of explosion in which result is 51.97 kW/m^2 to target at 10m distance.

Thermal dose: The thermal expression is give by

(Explosion) Dose= $I^{4/3} t$

Where, I= Incident thermal flux(kw/m^2) t = Duration of exposure (s)

Dose = $(51.97)^{4/3} \times 10$ (Assume t= 10 sec)

= 1914.0

This result conclude that thermal dose 1914$(kW/m^2)^{4/3}$ s effect is 50% lethality, members of the public.

Thermal dose Fatality criteria (use for fireballs)

Thermal Dose units $(kW/m^2)^{4/3}$s	Effect
1000	1% lethality
1800	50% lethality, members of the public
2000	50% lethality, offshore workers
3200	100% lethality

These two tables showed the rank and level of hazards:

Description	Rank
Very likely	4
Likely	3
Unlikely	2
Very unlikely	1

Description	Level
Extremely harmful	4
Harmful	3
Slight harmful	2
Very slight harmful	1

IV. CONCLUSION

The fire safety preventing methodologies helps in control various kind of hazards & accidents & reduce the rate of loss in many kinds of industries. This approach is to give a systematic way to minimize the fire & explosion hazard in a high risk area. This paper describe the general terms required to create a safe atmosphere under the guidance of various laws related to health & safety. The tool job safety analysis which is used in this paper describes the various levels of risk & hazard which is associated with a LPG bullet or storage tank by using calculation of explosion and the thermal dose. This paper may also helpful to recognizing all possible hazard & their effects on the atmosphere where accidents is happen in any of LPG storage area. There paper is may also represent a good technique to recognize hazard & minimize it.

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