Enhancement of chemical plant safety and study of different Type of Chemical Hazards Process

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Abstract:- *Considering today's scenario of population housing getting close to Industrial zones and we have witnessed many accidents that have caused injuries/loss of lives and damages to property and assets. This urges to understand the fire scenario and prevention of industrial hazards and thereby reduce/avoid the injuries, loss of lives and damages to the properties in vicinity of chemical industries. Accidents with explosives are not frequent because normally great care is used in handling these materials. Despite the detailed regulations governing explosives, their potential hazard is so great that it would be dangerous to assume that there will never be an accident or a failure to live up to basic safety precautions. There are different types of fire hazards like pool fire, fireball, flash fire, jet fire. Prevention method and controlling method are also discussed.*

Keyword:- *Fire Hazard, Chemical Hazard, Jet Fire, Pool fire, Fireball, Flash fire*

1. Introduction

Processes in the chemical, petrochemical, and hydrocarbon industries involve the handling of a wide range of flammable and explosive materials. Hazardous chemicals, such as flammable and combustible liquids, exist and are employed in a variety of settings. The inspecting authority might or might not be aware of this. When certain chemicals are mixed, dangerous reactions can occur. Some chemical compounds, when blended with combustible material, increase the combustible material's ease of ignition or the intensity of its burning. It's indeed necessary to understand the potentially hazardous reactions of individual chemicals in order to recognize the innumerable combinations of so-called incompatible chemicals. These material requirements' processing and storage operations provide numerous opportunities for their release and subsequent ignition. It is critical to assess the risk of fire in all materials and processes, including those used in production, manufacturing, storage, and treatment facilities. The release of flammable gas or liquid can result in various types of fire scenarios. These are determined by the material released, the mechanism of release, the temperature and pressure of the material, ambient conditions, and the point of ignition. This guideline focuses on fire protection. For the purposes of this guideline, ignition. This Guideline focuses on fire protection. For the purposes of this Guideline, fire protection and fire prevention are defined as follows: The study of limiting fire-related damage to life and property through control and extinguishment. Fire protection includes fire prevention, fire detection, fire control systems, and manual firefighting. Fire prevention refers to activities that aim to keep fires from starting. Fire protection and fire prevention are inextricably linked. All fire protection programs include a fire prevention program. Controlling ignition sources, for example, is critical in reducing the risk of fire but does not meet the Guideline's definition of fire protection. A significant portion of safety procedures is focused on avoiding catastrophic events such as fires and explosions. This is accomplished by containing hazardous materials within the processing system. The Center for Chemical Process Safety (CCPS) has developed a number of guidelines to assist organizations in this endeavor. The likelihood of potential consequences is frequently used to drive fire protection. Examples of fire-related incidents are offered in Table 1-1.

Year	Location	Incident Description
1984	Mexico City, Mexico	LPG Terminal—500 people were killed and the LPG terminal was destroyed by a major fire and a series of catastrophic Boiling Liquid Expanding Vapor Explosions (BLEVEs).

1998	New Brunswick, Canada	Process Facility —A fire started in the feed heater of a hydrocracker, resulting in one fatality and significant damage to a Hydrocracking Unit.
1998	Ras Gharib, Egypt	Terminal— After being struck by lightning, 16 tanks containing approximately 30,000 barrels of crude oil each caught fire.
1999	California, USA	Process Facility — A fire in a process unit caused three deaths, extensive downtime, and public scrutiny of refinery operations.
2000	Ohio, USA	Warehouse— A pharmaceutical warehouse fire caused damage to neighboring warehouses and a total property loss of $100 million.

Table No 1:- Examples of Major Fire Incidents

2. Define Fire Scenarios

Fires range in size and impact from small, easily manipulated fires that cause minor damage to large, difficult-to-control fires that cause major loss. Fires in process facilities are typically the result of a loss of containment. While the consequences of such fires are determined by a variety of factors (weather, wind, leak orientation, etc.), the following are the most important:

- The rate at which the spill occurs; and
- The total amount spilled

There are an infinite number of leak sizes in theory, ranging from a tiny pinhole to a complete rupture of piping or equipment. It is obviously impractical to investigate all of them. As a result, some practical advice on choosing leak sizes that allow for a reasonable range of fire scenarios is required. The process hazard analysis can serve as a starting point for developing fire scenarios. The process hazard analysis can be reviewed to generate a list of scenarios that result in fire. Table 5-1 shows the proposed generic release sizes for small, medium, and large releases. This saves time because it eliminates the need to create a detailed scenario. These release sizes can be used by the analyst to perform fire modeling calculations and determine the impact of moving the release point locations. As a result, some practical advice on choosing leak sizes that allow for a reasonable range of fire scenarios is required. The process hazard analysis can serve as a starting point for developing fire scenarios. The process hazard analysis can be reviewed to generate a list of scenarios that result in fire. Table 5-1 shows the proposed generic release sizes for small, medium, and large releases. This saves time because it eliminates the need to create a detailed scenario. These release sizes can be used by the analyst to perform fire modeling calculations and determine the impact of moving the release point locations. An FHA takes the approach of assuming release ignition. In reality, not every release causes a fire. The probability of ignition can be considered during the quantitative risk assessment process. However, in an FHA, it is critical to determine whether or not ignition sources are present for the fire scenarios to occur. In some cases, fire scenarios can be excluded from analysis due to a lack of a credible ignition source.

Type	**Release size, inches (millimeter)**
Small	0.1–0.4 (3–10)
Medium	0.4–2 (10–50)
Large	2–6 (50–150)
Rupture	Full-bore (equipment diameter)

Table No 2 :- Typical FHA Release Categories (Spouge, 1999)

3. Types of Hazard Chemical Process

Processes in the chemical, petrochemical, and hydrocarbon industries involve the handling of a wide range of flammable and combustible materials. These materials' processing and storage operations provide numerous opportunities for their release and subsequent ignition. It is critical to assess the potential for fire in all processes and materials including those used in production, manufacturing, storage, and treatment facilities. The release of a flammable gas or liquid can result in a variety of fire scenarios. These are determined by the material released, the mechanism of release, the material's temperature and pressure, ambient conditions, and the point of ignition. Types of fires include Pool fire, Jet fire, Flash fire, Boiling liquid expanding vapor explosion (BLEVE) or fireball and Flash Fire.

3.1. Pool Fires

Pool fires are turbulent diffusion fires that burn above a horizontal pool of vaporizing hydrocarbon fuel with zero or low initial momentum. Open fires will be well ventilated (fuel-controlled), but enclosed fires may become under-ventilated (ventilation-controlled). Pool fires can be either static (e.g., where the pool is contained) or 'running.' Pool fires are a significant component of the risk associated with major accidents on offshore installations, particularly in the Northern North Sea (NNS) where liquid hydrocarbon inventories may be large. ARAMAS, NEPTUNE, and PLATO are examples of software packages commonly used for offshore QRA studies. These codes appear to only model open pool fires, not the specific features of confined or ventilation-controlled fires.

3.1.1. Pool fire hazards

- There are major uncertainties in the behavior and properties of fires of condensate and higher molecular weight and multi-component materials and very large flames of all materials; behavior of running fires and of liquids released from pressurized containment
- The effects of water deluge and foam on fuel dispersion and pool fire mass burning rate, in addition to the effect of the pool shape of radiation and soot shielding, remain unclear.
- The effect of scale on fire size, geometry and radiation, particularly for very large fires and the ability to predict the overall behavior of large hydrocarbon pool fires in offshore structures is poor.
- The validity and accuracy of field model applications to offshore compartment fires are dubious.
- There is no difference in the rate of burning among pool fires on water and pool fires on steel.
- Fuel-controlled pool fires have rapid temperature increases (up to 1300 ° C) and high heat fluxes (up to 320 kW m-2) in insulated compartments.
- The burning rate (kg s-1 m-2) is not affected by pool area on a wide scale or external flame ignition requirements.
- The characteristics of pool fire propagate on steel plates are incompletely defined.

3.1.2. Strategy objectives

The following are the goals of this area of fire hazard evaluation:

- Classification of regions of unpredictability in pool fire classification;
- Identification of insufficiencies in hazard description and effective mitigation measures;
- Initiation of findings to increase understanding and understanding in ill-defined places of hazard definition; and
- Encourage the use of a consistent methodology for accurately assessing the dangers presented by pool fires.

3.1.3. Strategy development issues

- To specify the conditions under which exhaust vents pool fires might take place on offshore installations
- To develop simple tools for evaluating the risks posed by convection pool fires;
- To Once assessing hazards that also include constrained fires, specific consideration should indeed be managed to make; is spread of a flame across the roof of a subsystem and is there a possibility for external flaming?;
- To establish a knowledge of the current capability to model bound (fuel-controlled) pool fires;
- To analyze such concepts against suitable large-scale test data;
- To develop simple tools to assess the hazards posed by confined pool fires;

3.2. Jet Flames

A jet or spray fire is a turbulent diffusion flame produced by the combustion of a fuel that is continuously released with significant momentum in one or more directions. Jet fires can occur as a result of gaseous, flashing liquid (two phase), or pure liquid inventories being released. Jet fires are a significant contributor to the risk of major accidents on offshore installations. High heat fluxes to impinged or engulfed objects can cause structural failure or vessel/pipework failure, with further escalation possible. The rapid spread of a jet fire has significant implications for control and isolation strategies. The fuel composition, release conditions, release rate, release geometry, direction, and ambient wind conditions all influence the properties of jet fires. Low velocity two-phase releases of condensate material can produce pool-like flames that are buoyant, sooty, and highly radiative. Natural gas sonic releases can result in relatively high velocity fires that are less buoyant, less sooty, and thus less radiative. Current industry practice is to analyze jet fires for length of the jet fire in relation to plant equipment, buildings, population, and so on. The extent of impingement into the affected area, as well as the need for PFP, emergency depressurisation, and other mitigation options, are all taken into account. Personnel are assumed to be able to survive and escape from heat fluxes less than 5 kW m-2, but fatality is assumed for higher heat flux values. The effect of jet fires with high heat fluxes (for example, a flame temperature of 1350^{0}C and a heat flux of 400 kW m-2) is not generally considered in safety case assessments. This is due to the fact that these types of flame are not covered by current guidance.

3.2.1. Jet Fire Hazards

The hazards, characteristics and physical properties of hydrocarbon jet fires have been appraised in the Phase 1 reports of the Joint Industry Project on 'Blast and Fire Engineering of Topside Structures':

- The main source of detailed information on the characteristics of jet fires covered in the reports on the program of jet-fire research co-funded by the European Community (Bennett et al, 1990).

- Recent advancements in knowledge have been notable in the areas of unconfined crude oil jet fires and confined jet fires (compartment fires). These topics were investigated in Phase 2 of the JIP on 'Blast and Fire Engineering of Topside Structures,' as well as another JIP on releases of 'live' crude oil solution containing gas and water.

3.2.2. Strategy development issues

- To raise understanding of the effects of jet fires on pressurized structures, as well as the insufficiency of API 521 for fire attacks and the possibilities for under-sizing of pressure relief systems;

- To make people aware of the specific hazards posed by ventilation-controlled jet fires;

- To develop simple tools for determining the risks posed by convection cooling jet fires;

- To understand the heat flux from high temperature jet flames and the effects of exposure on pressurized storage vessels;

- To take into account mitigation and regulation problems related to jet fires inaccessible and restrained areas;

- To develop an understanding of the current capability to model confined (fuel-controlled) jet fires;

- To compare such models to appropriate vast test data;

- To create simple instruments for evaluating the dangers posed by bounded jet fires

3.2.3. Strategy objectives

- To identify areas of uncertainty in the characterization of jet fires;

- Determine the significance of the jet fire hazard in relation to certain other hydrocarbon hazards; initiate research to enhance understanding and knowledge in ill-defined areas of jet fire evaluation; and

- Promote the use of a consistent methodology for evaluation of jet fire hazards.

3.3. Fireballs and Flash fire

Accidental releases of flammable liquids or gases frequently result in the formation of a dense cloud of vapor relative to the surrounding environment. If the cloud comes into contact with an ignition source, a vapor cloud fire (VCF) may occur. In this context, VCF refers to either a flash fire or a fireball. VCFs are significant for two reasons: An inherent hazard in the form of thermal radiation, assuming no or limited confinement/congestion and thus no overpressures. Escalation is a possibility. Secondary fires are likely to be started as a result of the flash fire / fireball, and there is a high likelihood that there will be a steady fire following a VCF, typically either a pool fire or jet fire.

3.3.1. Strategy objectives

- To identify areas of uncertainty in the characterization of flash fires and fireballs;
- Determine the significance of the fire hazard in relation to those other hydrocarbon hazards.
- Initiate research to increase knowledge and understanding in ill-defined areas of flash fire and fireball evaluation; and
- Promote the use of a consistent methodology for evaluation of fire hazards.

3.4. Fireballs/BLEVE's and Flash fire hazards

An overview of the incidents, experimental data and the methods for estimating the characteristics of vapor is given in the 'Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions,

- Fireballs/BLEVE's

  1. The dimensions and shape of the fireball produced by a vessel's BLEVE failure were determined by the amount of fuel in the vessel and the mode of failure.
  2. The resulting external radiation field, and thus the received dosage, is affected by fuel mass, wind speed, and orientation.
  3. The period of the fireball was observed to be proportional to the quantity of fuel involved.
  4. Surface emissive power is highest for the smallest release, because a smaller mass is superheated such that, it flashes to vapor most rapidly, producing a highly radiative flame.
  5. The resultant fireballs gave their maximum power output before the fireballs reached their maximum volume and close to the lift off time.

- Flash fires

  - The presence of obstructions in the path of the vapor cloud was found to alter the concentration of LPG vapor in the cloud dramatically with, in this case, there is decreases in the vapor concentration.
  - The concentration of gas in the vapor clouds formed was generally low and the vapor cloud fires produced were relatively lean. The flames were therefore often invisible. Ignition of the cloud was observed at concentrations below the Lower Flammability Limit (LFL) of 2.2 vol.%.
  - This is thought to be due to localized pockets of high concentration of gas at locations where the average concentration is measured as being below the LFL. In no cases were fireballs observed.

Strategy development issues

- To develop simple models to predict the occurrence and effect of vapor cloud fires.
- To develop a greater understanding of the effect of flash fires on personnel.
- To develop a methodology to identify scenarios where a flash fire develops into a vapor cloud explosion.
- To develop an understanding of the current capabilities of models to address fireballs and flash fires and to predict the consequences of each.

4. Controlling and Prevention Measure

Generally the principles of controlling the fire and hazards associated with explosives include the following.

- Eliminating sources of fire.
- Providing proper storage facilities and sites.
- Controlling storage and use.
- Providing special remote and isolated storage and manufacturing sites.
- Separating different explosive materials in storage.
- Eliminating all ignition sources.

Explosive fire prevention measures embrace one or more of the following techniques.

- Identifying substances correctly.
- Handling by qualified personnel.

Conclusion

Processes in the chemical, petrochemical, and hydrocarbon industries involve the handling of a wide range vapors relative to the surrounding environment chemicals, such as flammable and combustible liquids, exist and are used in a variety of settings. In chemical plant layout consideration, there is necessity to develop a simple and acceptable way of working to determine safety distance in case of fire scenario and in case of leakage of toxic substance. Chemical industries are among the most dangerous in the world. Furthermore, despite the fact that enormous efforts have been made in numerous nations to improve security execution, the development sector continues to lag behind most other ventures. The main objective was to define a philosophy to determine suitable separation distance between storage tanks and object to allow design engineers to develop consistent standard across the industry that also can be used as basis for submitting for approval of chemical plant layout from local governing/regulating bodies. Q Pool fire, jet fire, flash fire, boiling liquid expanding vapor explosion (BLEVE) or fireball, and flash fire are all examples of fire hazards. All of this is covered with strategy objective and development issues. This review paper provides an overview. In general, the principles of controlling and preventing fires and the hazards associated with explosives are also discussed.

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