CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

One may be forgiven for believing that process safety is a single action with the aim of preventing a fire, explosion once it has started. The truth is that process safety is a process that begins with assessing the dangers present in the environment in order to prevent fires and subsequent explosions that could release toxic materials, for example, from chemical process facilities, refineries and oil & gas installations.

Risk assessment is a study to analyse, identify and evaluate the hazards and risks in process industries and develop control measures to reduce the risks that may cause fires and the release of dangerous elements in to the environment. Risk Assessments have now become a legal requirement for setting up a process industry in many countries.

Qualitative risk assessment techniques such as Job safety analysis (JSA), (Hazard Identification and Risk Analysis) HIRA, what-if methods, checklist, Safety Inspection, Safety Audit etc. aim to identify the hazards and assess the risks using comparison methods.

Major industrial accidents such as Flixborough in 1974 (Dunton, 1974), Seveso disaster in Italy in 1976 (Lees, 1996), Bhopal gas tragedy in India, 1984 (Union Carbide Corporation, 2016), Piper Alpha disaster in North Sea 1988 (Piper Alpha Platform, North Sea, United Kigdom, 2016), Deep water horizon oil spill in Gulf of Mexico 2010 (Deepwater Horizon accident and response, 2016) had huge impacts to the environments and societies in which they operated. These accidents could have been prevented if safety processes had been implemented effectively in these facilities [61]. In order to prevent such major accidents, calls to enhance the safety management systems were made.

The risk assessment study has now become a standard safety tool to be used for land use planning, design of safety shutdown systems, interlock systems and gas detection systems. Where Quantitative Risk Assessment (QRA) methods were carried out using simple tools such as spread sheets, those tools have evolved into sophisticated software or Computer Aided Modelling tools [71]. Overall from the QRA results, the risk to the individual and society is assessed and control measures are accordingly developed and implemented.

1.2 RESEARCH PROPOSAL

Quantitative Risk Assessment (QRA) is a study that aims to identify the hazards and risks of a process facility and the consequences that could have on people, the assets, environment in which it operates and the reputation of the organization. The QRA is not only more realistic but also has many other advantages over a qualitative approach.

Based on the QRA study, the safety aspect of land use planning, safe distance from hazardous installations and emergency & disaster management plans can be derived. The Risk Assessment study also aims to assess the individual & societal risk, with the results being presented in Risk Contours / transects and F-N curves where the risk levels are compared with the established risk acceptance criteria for decision making. The loss of containment (LOC) of flammable gas results in fire and explosion accidents are also analysed. In this QRA's study the failure data of process equipment is used to assess the frequency of loss of containment scenarios. Usually the failure data are collected from generic databases such as the Offshore Reliability Data (OREDA), European Industry Reliability data bank (EGIG), Center for Chemical Process Safety (CCPS) data base etc. But these databases have certain limitations, thus the quantification of risk using this data may not always be accurate and the validity of the results can be challenged.

Moreover, these databases do not have failure data for all the equipment or components. For example, flammable gases such as Liquefied Petroleum Gas (LPG), Liquefied Natural Gas (LNG) and Hydrogen gas are being widely used and the adoption of Natural Gas (NG) and hydrogen are fast paced in India and other developing countries. In order to cater for the energy demand many NG import terminals and cross country transmitting pipelines are now under construction. Therefore reliable Risk Assessments are vital. But the failure data related to LPG / LNG /NG/ Hydrogen gas facilities are very rare. Moreover, the results of Risk Assessment studies conducted are highly inconsistent.

This research report is an attempt to discover a method which is able to generate consistently reliable data, and to derive a model that can reliably predict failure data with respect to plant specific conditions. A methodology is to be developed using existing generic failure data and limited plant specific conditions in order to update the failure frequency.

1.3 QRA STEPS

A typical QRA study has the following main steps:

- Hazard Identification;
- Consequence Analysis;
- Frequency Analysis;
- Risk Analysis;
- Risk Evaluation;
- Risk Management.

Hazard Identification is the principal step in risk assessment. The hazards must be identified using different tools according to the material and equipment being assessed, such as flammable or explosive. The materials used in its composition, operating temperature and operating pressure of the facilities, storage condition and its parameters help to identify the hazards more accurately. This information can be derived from the process plant drawings and other available information such as operating manuals and procedures.

The Hazard Identification (HAZID) study shows us how the hydrocarbon material could possibly escape from its containment and result in fire, explosion as well as toxic release. The operational hazards of the process facility are normally captured by the Hazard and Operability study (HAZOP) tool.

Consequence Analysis is an integral part of risk assessment. Manual calculations are used to find blast over pressure and radiation intensity from any fire or explosion that may have occurred earlier. In present day, sophisticated software models are used to assess the physical effects of risk in the process plants. Jet fire, pool fire, vapor cloud fire, vapor cloud explosion, toxic cloud and various outcome cases are analysed.

Frequency Analysis is the methodology to evaluate failure frequency, i.e., number of occurrences of a hazardous accidents scenario in a year. Estimates may be obtained from generic or historical databases or from any failure prediction models such as Fault Tree Analysis (FTA). Risk analysis is the part of the QRA study that evaluates risks by combining this frequency of hazardous events with the consequences of hazardous events.

Risk evaluation: Risk can be expressed in many ways such as individual risk, societal risk, location specific risk etc. Risk may be present in many different ways for chemical processes. Oil & Gas facilities, for example, express their risk as contours / transects and F/N curves.

Risk management: Based on the results of risk value which is compared with risk acceptance criteria, risk is evaluated for individual and societal risk. Risk controls and mitigation measures are developed to reduce the risk to 'As Low As Reasonably Practicable' (ALARP) level.

In many countries, QRA studies are mandatory according to law before starting any hazardous operations and installations. They are used at various points in the process of land planning, site selection & layout finalization amongst other things.

In India the Environmental Impact Assessment study calls for a detailed risk assessment study for any hazardous installation. LPG, Natural gas, Hydrogen, CNG gases are used in many industries. LPG is used very widely in India, while Natural Gas and Hydrogen usage on an increasing trend. It is estimated that Natural Gas usage will reach approximately 400 Million Metric Standard Cubic Meter per Day (MMSCMD) in India during 2015.

1.4 MOTIVATION FOR THE RESEARCH

Risk assessments are carried out for hazardous installations taking into account the life cycle of the plant. During the design stage QRA studies are carried out to estimate the risk in order to manage that risk. Risk levels of flammable gas facilities are computed using Event Tree Analysis, Consequence Analysis, and Vulnerability Analysis. It is important to assess the risk of flammable gas facilities and its transmission network.

Natural Gas and Hydrogen gas appear to be the future energy source for India as demand for these gases continues to increase. These gases are mostly used for electricity generation in commercial and industrial installations while their use as alternative fuel for automobiles also continues to grow. If these trends continue unchecked, then catastrophes such as the Bhopal gas tragedy in 1984, the Fire at the IOC terminal and Vizakapattinam Refinery are still a high possibility and very much a probability.

Presently the researcher is working as a safety officer in Qatar Petroleum at Raslaffan Industrial City. Raslaffan Industrial City is in Qatar, and is recognised as one of the main hubs for LNG operations and in the world. The Natural gas taken from North Field of Qatar is transported through pipelines to this port. Here the LNG is treated and purified. LNG is exported through this port as well as providing raw gas to downstream liquid industries. Raslaffan Industrial City consists of storage tanks, pipelines and export terminals for liquid products. World class operating companies such as Shell, Total, Occidental, Chevron and joint ventures such as Ras Gas and Qatar Gas also operate plants within the industry.

The experience in the industry has motivated the researcher to gain knowledge in technical safety standards and likely to contribute in risk assessment of flammable gas facilities.

1.5 RESEARCH OBJECTIVES & SCOPE

The study objectives for this research are:

i. To identify the HSE hazards (HAZID/HAZOP) and threats that can be applied to credible accidental scenarios;

ii. To carry out fire, explosion, flammable gas dispersion modelling to assess the physical effects for the selected scenario.

iii. To assess the frequency by FTA / ETA or from generic historical database in order to assess the consequences on people and equipment/structures.

iv. To estimate the risk of fatality to personnel arising from flammable hydrocarbon and toxic releases risk and mapping them on risk contours / transect / F-N curves;

v. To establish a method to generate precise failure frequency data for the QRA.

The scope of this research work will relate to the area of frequency analysis. Many methods and techniques are followed for assessing frequency risk assessment of flammable gas facilities. Fault Tree Analysis, Event Tree Analysis, Layer of Protection Analysis (LOPA), Fuzzy Fault Tree Model, historical or generic failure data assumption and Parts Count Approach Methods (PCAM) are also used. Local plant specific failure data shall be incorporated with historic or generic data by using Bayesian approach and PCAM.

1.6 STRUCTURE OF THE REPORT

This report contains the following structured manner and each chapter is put in order to achieve the research work objectives:

Chapter 1

Covers the general introduction, research proposal, QRA steps, motivation for this research work and objectives, research scope and structure of the report etc.

Chapter 2

This chapter deals with the detailed literature survey about risk assessment studies practiced by process industries, especially in the oil and gas industry. The papers published in oil and gas flammable gas facilities risk assessment studies are reviewed, and QRA methodology followed for risk assessment study and typical risk assessment flow chart, hazard identification tools, quantitative as well as qualitative methods, consequence and frequency analysis, historic & generic databases etc. are covered in this chapter.

Chapter 3

This chapter covers the research methodology followed in this research work. The steps adopted are explained in details such as HAZID / HAZOP study, teams, applied in various case studies of different oil and gas facilities. Various qualitative and quantitative tools are described and appropriate hazard identification tools are used in this work with a describing their advantages and limitations. Consequence and frequency modelling used and appropriate soft wares, assumption criteria are elaborated.

Chapter 4

Chapter 4 deals with the modelling and Analytical part followed in this research work. Hazardous scenarios are developed and various hazardous event outcomes are evaluated. How the consequence and frequency calculation are based on PCAM and Bayesian network are carried out and how the failure frequency are influenced by this work are explained. This covers the equipment counts, and the parts and components of selected flammable gas facility. The PCAM method is used to analyse and synthesise the failure frequency adopting the local failure frequency using the Bayesian Network, which is explained in this chapter.

Chapter 5

Chapter 5 covers the research work results and its interpretation and how contributions are enhanced to obtain the updated failure frequency and the accidents presently happening across oil and gas industries.

Chapter 6

Chapter 6 covers the conclusion of the research work, main contributions and future research work.

Chapter 7 and 8

These chapters include references, papers published & accepted for review, abbreviations, appendices, check list, calculations, charts, figures and tables. The curriculum vitae of the research scholar is also included.