STUDY OF ACCIDENT PATTERNS IN OIL AND GAS INDUSTRY (UPSTREAM) AND VERIFICATION WITH ACCIDENT CAUSATION MODELS

By

SIVA PRASAD PENKEY
COLLEGE OF ENGINEERING

Submitted

IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF
DOCTOR OF PHILOSOPHY

To

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

DEHRADUN

August 2016

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Dedication

This thesis is dedicated to my parents, wife and daughter who always stood by me and supported in continuing education and dealt with all my absence from many personal occasions with a smile.

This thesis is also dedicated to Bharat Ratna Dr.A.P.J Abdul Kalam, a true human and former President of India whose journey from Rameswarm to Rastrapathi Bhavan has inspired and motivated me to carryout research and bring the thesis to this level.

Siva Prasad Penkey

Date: 27th June 2016

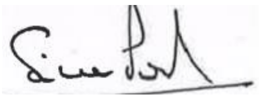
APPEAL

TO ALL THE STAKEHOLDERS OF
OIL & GAS (UPSTREAM) INDUSTRY

I respect national and international standards; their administration and enforcing bodies, accident prevention process implementers, Oil and Gas (Upstream) stakeholders for their contribution in prevention of accident and personal injuries at work place. I respect all Oil and Gas (Upstream) stakeholders for ensuring all possible controls in prevention of accidents.

The stakeholders of this business are humbly requested to consider the gaps mentioned in this research work not to be treated as criticism on any specific clause in any standard or on standards enforcement authority or on any specific person or on any specific industry or organization.

With due respect, I appeal all stakeholders to consider the recommendations given in this research work are purely to improve the current practices of accident causation, accident analysis and to prevent work place injuries with noble intentions reflecting every life is equally important.

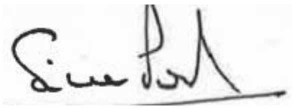


Siva Prasad Penkey

Date: 03 August 2016

DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.



Siva Prasad Penkey

Date – 03 August 2016

SAP ID P500011023

THESIS COMPLETION CERTIFICATE

This is to certify that the thesis entitled ***"Study of Accident Patterns in Oil and Gas Industry (Upstream) and Verification with Accident Causation Models"*** submitted by ***Siva Prasad Penkey*** to ***University of Petroleum and Energy Studies*** for the award of the degree of ***Doctor of Philosophy*** is a bona fide record of the research work carried out by him under our supervision and guidance. The content of the thesis, in full or parts have not been submitted to any other Institute or University for the award of any other degree or diploma.

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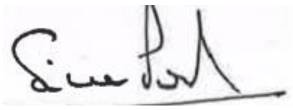
I am especially thankful to my wife Ms. Kiran Penkey, my daughter Tejaswini Penkey for their enthusiastic support in listening the thesis script and helping in preparing the same.

I am thankful to my parents for their unconditional love and blessing for any of my achievement. Special thanks to my father Sri Krishna Murthy Penkey, who commanded and encouraged me all the time achieving significant milestones.

I also express my thanks to in-laws and all my close family members for their co-operation, understanding and support during the course of my research.



Siva Prasad Penkey

EXECUTIVE SUMMARY

Petroleum Industry is the backbone for any country's economic development and social strength. However, Oil & Gas Exploration, Production and Pipeline transportation are involved with high risk activities. The accidents occurred or continued to occur in the industry had a significant impact on personnel, environment or assets.

Operations of Oil and Gas facilities are exposed to greater risks involving personnel, environment and property. Low frequency and high impact incidents have caused significant human loss in the industry. The accidents caused in Oil and Gas Industry resulted in significant human loss. Human errors are the major root causes of any industrial accidents. It is also truly applicable to Oil & Gas Industry. Unsafe practices such as unsafe conditions and unsafe acts are basic causes of most accidents.

Over the recent years, technology is rapidly changing and automation is taking place for better controls, better productivity. Accordingly, newer risks influxes into work place activities and when controls fail accidents are caused.

The crisis of current low Oil prices is another dimension of increasing threat of environmental incidents, workplace injuries resulting in human loss due to forced cost cutting on Oil and Gas operations. Experience has demonstrated that 'cost cutting' can result in undesirable reductions in the protections that are needed to be 'safe'. More than 350,000 people laid off in the oil and gas industry worldwide during 2014-2016.

"It is analogous to driving a car without a speedometer and being told and required to 'drive safely'."

However, the industry reacts to any major incident that has caused human loss and any environmental or property damage. It is failing to understand or learn lessons to prevent recurrence. This could be attributed to failure to recognize the safety management controls and personnel behaviours at work site, failure to recognize the hazards, at risk behaviours, root causes of the incidents and failure to understand the pattern of accidents. Now, many organizations are looking at changing from legislative compliance to positive proactive measures. In order to achieve these objectives, one has to focus on understanding the common root cause of the accidents pertinent to Oil & Gas Industry.

Therefore, further understanding the accident patterns and weak links in the process of accidents occurrence, evaluation of relevant models for mitigation of accidents could be a recognizable research in the field of Health, Safety & Environment.

Every accident is associated with different type of failures with different root causes. Repeated disasters are revealing that safety management failure to ensure proper barriers in place is the common root cause. For that effective safety programs which prevents the accidents should be in place to deliver the benefits in terms of tangible and intangibles. Good safety practices have to be recognized by employers and the contractors in prevention of accidents. It is the duty of the personnel working in the Oil and Gas sectors, to protect the personnel, environment and at the same time pursue the goal of economic development. Every life is equally important should be the theme.

Many accident occurring theories have evolved to give reasoning with its occurring and to understand the pattern. Also varieties of accident investigation models are in use to analyse the accident causes and accordingly propose recommendations to prevent reoccurrence.

Motivating from the above context, current research is focused on studying the patterns of accidents occurred in Oil and Gas fields, root causes of the disasters, significant contributors for the accidents including human factors, attitudes, different work patterns, environmental conditions. Also the research verified that how the Oil and Gas Industry conceptualised the accident occurs, the relevance of existing accident models, influence of inherent human factors.

The scope of the research includes Oil and Gas Upstream activities viz. Exploration, Drilling, Production and transportation. The source of the sample data for the research is from benchmarking reports of International Oil & Gas Producers (IOGP) and focused accident analysis reports of Cairn India Limited's Oil & Gas assets located in India.

The Objectives of the current research are divided into five broad categories and are:

- Carryout Research in identifying the pattern of accidents occurred in Oil and Gas facilities.
- Compare the accident causations of Cairn India with Other accident causation models to identify similarities or gaps.
- Study the inherent risk factor including human attitudes that are contributing to accident in Oil and gas exploration and production facilities.
- Study the current methodologies of accident root cause analysis that the Oil and Gas Industry adopted and suggest improved method.
- Suggest Recommendations

The methodologies for the research work adopted are survey research, review of disasters occurred in Oil & Gas Operations worldwide, review of accident causation models, suitability of various models and influence of inherent human attitudes in accident patterns.

From the benchmarking reports published by International Oil & Gas Producers (IOGP), during the year 2014 there was about 51% reduction in fatal accident rate. It is further reported that 78% of fatal accidents would have been averted by following lifesaving rules. These lifesaving rules are directly related to human attitudes and work place safety behaviours.

There are a number of common causal factors appeared consistently in the top ten for both fatal incidents and high potential events for each of the past five years.

- Organizational: Inadequate training/competence
- Inattention/lack of awareness: Improper decision making or lack of judgment
- Organizational: Inadequate work standards/ procedures
- Organizational: Inadequate supervision
- Organizational: Inadequate hazard identification or risk assessment.

A specific survey form has been designed objectively and circulated to field personnel of various parts of Oil & Gas Industry. More than 350 such feed backs have been received and analysed. The survey form composed of 15 elements covering the basic understanding of Heinrich theory of accident occurring, relevance to Oil & Gas, significance of root cause analysis, importance of safety barriers in prevention of accident occurring. Field safety personnel, line managers, group managers, contractor representatives, work site supervisors, graduate engineers have participated in the survey. The samples were obtained from Oil & Gas operations spread over in India, Aberdeen UK, Canada, Kuwait, Saudi Arabia, Qatar Petroleum, Bahrain and UAE.

The survey supported the current research with the following:

- All accidents are preventable
- Heinrich theory of accident occurring is not fully satisfying the causation of accident occurring in Oil & Gas.
- Barriers are very important in prevention of accident occurring.
- Failure to identify the hazards and ensuring risk controls are the cause of the accident occurring.
- Inadequate root cause analysis or lack of skills are the deficiencies in identifying the accident occurring.
- Attitude of work force is having direct relation to accident occurring.
- Behavioural changes may reduce the accidents.

The results of the research objective emerged with the following:

- Failure of safety barriers leading to disasters in Oil & Gas.
- Heinrich theory of accident occurring is not fully satisfying the causation of accident occurring in Oil & Gas
- Inadequate hazard identification, Job supervision and lack of competency are the causes for work place serious injuries.
- Behavioural safety and cultures is still the weakest link in accident occurring in Oil & Gas operations.
- Attitude of work force is having direct relation with accident occurring and behavioural changes may reduce the accidents.

The second research Objective is to "Compare the accident causations of Cairn India with Other accident causation models to identify similarities or gaps".

More than 2500 accident cases have been analysed and compared with Heinrich theory of accident occurring. Focus was drawn on the influence of age factors, activity, types of injuries and experience of the personnel.

The results of the said objective are as follows:

- The patterns suggested by Heinrich is not accurately justifying the patterns of accidents that are occurring in Oil & Gas industry.
- Personnel between age group of 20-30 years in Cairn India are found to be more in work place injury exposure.
- Caught between, dropped objects, slip/trip and fall are similar in Carin India E&P activities when compared with other similar companies.
- More serious injuries are resulting from Drilling activity in Cairn compared to others.

The results of third objective "Study the inherent risk factor including human attitudes that are contributing for accident in Oil and gas exploration and production industry" are:

Organisations with the best and consistent safety culture identified the human attitudes are the key component of accident occurrence. A field research work was carried out designing a program which included Personal factors, Job factors, Unsafe Acts, Unsafe Conditions, Personnel Protective Equipment and Tools & Equipment. More than 1000 personnel were trained in identifying the basic hazards at work place, at-risk behaviours of the personnel and other factors. The program was tested for Cairn India's Up-stream Oil and Gas facilities for a period of three years. The output of the Observations was analysed. The results of the research found to be:

- Personal attitudes are directly related to accidents.
- Failure to recognize the hazards causing the accidents.
- Consistent Behavioural interventions preventing the work place injuries.
- Near misses are significant part of accident occurring.
- Recognizing the nearmises, analysing the root causes and preventing the reoccurrence contributes to reduction of accident.

The illustration and results of fourth objective "Study the current methodologies of accident root cause analysis that the Oil and Gas Industry adopted and suggest improved method" are:

Oil and Gas currently uses various accident analysis techniques and methods to identify the root causes.

Root cause analysis (RCA) is one of the technique widely used in Oil and Gas Operations. It is a process designed for use in investigating and categorizing the root causes of events with safety, health, environmental, quality, reliability and production impacts.

The other techniques are 5 Whys analysis techniques. It is using 5 Whys which doesn't always lead to root cause identification when the cause is unknown. That is, if the cause is unknown to the person doing the problem solving, using 5 Whys may not lead to any meaningful answers.

This technique depends on to some degree contingent upon the skill with which the method is applied; if even one Why has a meaningless answer, the whole procedure does not yield the result. It is also not dependency of repeatability. If three different personnel applying 5 whys to the same problem may come up with totally different answers. It is also having limitation in distinguishing between causal factors and root causes.

Bow-tie analysis is a visual tool gives the effectiveness of barriers preventing a top event resulting from a hazard. The analysis depends upon the skill of the personnel performing the analysis. During the current research work this is widely used and inferred that this technique is giving opportunity to identify the barrier failures. The focus of this technique is driving from the ways the release of inherent hazard leading to a top event when designed barriers fail. Also the recovery mechanism of the incident release and the effectiveness of the barriers helping the investigator. From the literature survey it is interpreted that bow-tie method of accident analysis is a structured assessment and communication of risks and clearly demonstrates the link between control measures and management system arrangements. It can be used to qualitatively assess and demonstrate control of all types of risks. However, it further needs inputs of the individual carrying out the analysis.

Fish-bone analysis, a cause and effect diagram, often called a “fishbone” diagram to identify possible causes of a problem and in sorting ideas into useful categories. A fishbone diagram is a visual way to look at cause and effect. However, the success of this technique depends on the knowledge and skills of the analyst.

Swiss cheese Model is an understanding of accident causation.

It links human systems to multiple slices of Swiss cheese, stacked side by side, in which the risk of a threat becoming a reality is mitigated by the differing layers and types of defence which are "layered" behind each other. Therefore in theory, lapses and weaknesses in one defence do not allow a risk to materialize, since other defences also exist, to prevent a single point of weakness. It is having limitation of integration with other mathematical models.

Barrier based Systematic Cause Analysis Technique (BSCAT) is a method that links modern risk–based safety management approaches to systematic root cause incident investigation. The model is a sequence of dominos establishing the hierarchy of accident progressions of the immediate cause back to fundamental root causes and system failures.

The current research work has extensively used the BSCAT technique to analyze the root causes of various incidents of Oil & Gas. It is inferred that it is providing an opportunity for analyzing the root causes in more structured way.

The results of this objective are:

- To identify root causes of an incident many analytical tools are available. Each tool is having its own limitations.
- These tools often fail to provide the true underlying causes.
- These advanced tools depend on the specialist's judgment doing the analysis.
- Failure of human factor quotients to be considered in analysing the accidents.
- The Attitude Barrier Model is useful in analysing of major accident in respect to contribution of human factor.
- Human factor are related to major hazard accident.

- The fifth Objective of this research work is to propose recommendations based on the outcome of the analysis for better understanding the accident occurring in Oil & Gas Operations.

  These recommendations are:

- Recognize that Oil & Gas Industry accident patterns are different compared to other industries.
- Oil & Gas Management to focus on inherent safety.
- Importance to be given to identification of hazards, Safety barriers and human factor
- Oil & Gas industries to evaluate specific safety promotional programs addressing, Consistent Behavioural interventions to prevent the work place injuries.
- Near miss are significant part of accident occurring.
- Oil & Gas Industry to recognizing that nearmis incidents are part of accident occurring. Therefore, emphasis to be given to analyse.
- Oil & Gas Industry to design Behavioural intervention programs specific to their activities.
- Industry may adopt the Attitude Barrier Model (ABM) while evaluating the root causes.

- Industry to promote safety culture of identifying the human factors as core component of major hazard accident.

The literary contributions from the current research are:

- Carried out in-depth study of accidents that have occurred in Oil & Gas (Upstream). Verified the relevance and interpretation of Heinrich theory of accident occurrence in Oil and Gas (upstream).
- Influence of critical factor like age of personnel, shift patterns, hazard identification, risk controls in accident occurring.
- Details study was carried out for the serious accidents occurred at Cairn India an Oil and Gas (Up-stream) and identified specific gaps in their safety systems.
- Detail study of various accident causation and accident investigation models. Proposed a new model of accident occurring involving human factor.
- Study the inherent risk factor including human attitudes that are contributing for accident in Oil and gas exploration and production industry.

Following advantages is expected from the implementation of research recommendations.

- Human factors are directly related to major disaster in Oil & Gas (Upstream) operations. Therefore, if the Organisations incorporate the mitigation methods there would be significant life savings through prevention of accident.
- Though Heinrich theory illustrating the accident occurring, Upstream Oil and Gas to interpret further more inherent risk factors of human behaviours. The accident occurring ratios is different for Oil and Gas operations from Other Industry.
- The suggested model of accident occurring is having specific advantage for Oil and Gas (Upstream) in prevention of accidents. It is providing an

- Opportunity for predicting the accident occurrence especially the inherent factors like influence of person's age, experience and other working conditions.

Thus the research concludes with the solution to address the inherent human factors, hazard identification, effect and correction of at-risk behaviours in accident patterns of Oil and Gas (Up-stream).

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CHAPTER 1.
INTRODUCTION

Petroleum Industry is the backbone for any country's economic development and social strength. However, Oil & Gas Exploration, Production and Pipeline transportation are involved with high risk activities. The accidents occurred or continued to occur in the industry had a significant impact on personnel, environment or assets.

The accidents caused in Oil and Gas Industry resulted in significant human loss. Human errors are the major root causes of any industrial accidents. It is also truly applicable for Oil & Gas Industry. Unsafe practices such as unsafe conditions and unsafe acts are basic causes of most accidents. Frank Bird's accident causation theory which was accepted worldwide describes that there are number of underlining causes for any accident to occur. Scientific analysis and interpretation of root causes of accidents reveals that human errors are the weakest link.

Over the recent years, technology is rapidly changing and automation is taking place for better controls, better productivity. Accordingly newer risks influx into work place activities and when controls fail accidents are caused.

However, the industry reacts for any major incident that has caused human loss and any environmental or property damage. It is failing to understand or learn lessons to prevent recurrence. This could be attributed to failure to recognize the safety management controls and personnel behaviours at work site, failure to recognize the root causes of the incidents and failure to understand the pattern of accidents. Now, many organizations are looking at changing from legislative compliance to positive proactive measures. In order to achieve these objectives, one has to focus on understanding the common root cause of the accidents pertinent to Oil & Gas Industry.

Therefore, further understanding the accident patterns and weak links in the process of accidents occurrence, evaluation of relevant models for mitigation of accidents could be a recognizable research in the field of Health, Safety & Environment.

1.1. GENERAL

Exploration of energy resources has played an important role in generating and sustaining individual development and economic growth. The consequences (Anon, 1995) of increased use of these hydrocarbons resulted in environmental degradation and other potential hazards including the danger of loss of human life and property damage.

Operations of Oil and Gas Industry are exposed to greater risks involving personnel, environment and property. Low frequency and high impact incidents have caused significant human loss in the industry. However, every accident is associated with different type of failures with different root causes. Repeated disasters are revelling that safety management failure to ensure proper barriers in place is the common root cause. If the industry is educated with the pattern of accidents and occurrence of incidents with root causes, it can act proactively to prevent human loss or damages. For that effective safety programs which prevents the accidents should be in place to deliver the benefits in terms of tangible and intangibles. Good safety practices have to be recognized by employers and the contractors in prevention of accidents. It is the duty of the personnel working in the Oil and Gas sector, to protect the personnel, environment and at the same time pursue the goal of economic development. Every life is equally important should be the theme.

The Oil and Gas Industry had witnessed and continue to witness the disasters viz. Piper alpha the world’s worst Oil & Gas disaster where in 164 people have lost their lives and Deepwater Horizon[15], resulting in explosions and fire on the rig, Eleven people lost their lives, and 17 others were injured followed by Oil spill of International significance. Bombay High North (BHN) platform disaster resulted in loss of 22 lives and operational asset loss.

The industry has adopted accident occurring theories proposed by various authors. However, understanding the accident causation is the significant on its prevention.

There are linear models which suggest one factor leads to next and to the next leading up to the accident and there are complex nonlinear models which hypothesis multiple factors are acting concurrently and by their combined influence, lead to accident occurrences.

Incidents have been defined as an undesired event that has caused or could have potentially caused personal injury, illness and / or damage (loss) to assets, production or harm to environment or company reputation.

1.2. MOTIVATION FOR RESEARCH

The hydrocarbon sector plays vital role in the economic growth of the country. India has total reserves of 775 million metric tons of crude oil and 1074 billion cubic meters of natural gas.

The total number of exploratory and development wells and meterage drilled in onshore and offshore areas are 381 and 888 thousand meters respectively.
Crude oil production during 2014-15 is 770 BBL/D//1K (Source: Trading Economics and reported by U.S Energy Information and Administration)
The refining capacity in the country increased to 177.97 million tons per annum (MTPA)

The number of million man-hours worked (including contract employees) in petroleum industry reached 4500 in 2014 (Ref: International Oil and Gas

Producers annual report). It indicates the growth in the business and the engagement of workforce which is directly related to the risk of work place injuries.

The disasters occurred in Oil and Gas Industry in worldwide Viz Piper Alpha, North Sea, where in 164 personnel lost their lives, BHN disaster of ONGC wherein 22 personnel lost their lives, Disaster of Deep water horizon, Macondo well incident which caused significant environmental damage etc., are the triggers to re-verify the accident patterns and understand the accident causations. The depth of identifying the root causes and actions to close every single week link helps the Oil and Gas Industry to prevent accidents. The rise in Oil & Gas disasters in India including Pipeline explosion and fire at Andhra Pradesh, Jaipur Oil terminal fire, Hazira terminal fire incidents are warning symptoms to understand the pattern of accidents and propose control mechanisms.

The researcher is having 29 years of industry experience in Health and Safety domain and experienced in safety management systems and leadership role. Further he is having exposure to accident prevention programs and investigation of various accidents and proposing the recommendations. He is also having a credit of six paper presentations on various Health and Safety issues nationally and internationally. Therefore self-motivation is an added value to the proposed research.

Twenty five safety awareness surveys of various organizations (petroleum and non-petroleum industries) in various locations in India reveal that the level of safety awareness (on accident occurring pattern) among managers is within the range of 75-85% and among the shop-floor personnel it is within the range of 70-80%. Hence there is a scope of nearly 25-30% improvement in safety awareness level of employees. Eighty to ninety percent of accidents are triggered by unsafe acts or behaviours. Thus, there is a need to further understand about specific causes of accidents pertinent to Oil and Gas fields.

1.3 RESEARCH SCOPE

The scope of the current research is “study of accident patterns in Oil and gas industry (upstream) and Verification with accident causation **models**. It is to verify the accident occurring patterns in Upstream including human factors, interpretation of accident causation models, testing of various existing models, interpretation of accident root causes of Oil and Gas disasters.

Figure 1: Representation of Research work

The above figure is illustrating the overall concept of the research work and its outcome which includes the Hazards, barriers, human factors, accident and injury.

1.4 RESEARCH OBJECTIVE

The study is designed at every stage keeping in view of the following objective

1. To carryout research in identifying the pattern of accidents occurred in Oil and Gas fields.
2. Compare the accident causations of Cairn India with other accident causation models to identify similarities or gaps. The outcome will help the industry to focus on their accident prevention programs to prevent accidents.
3. To Study the inherent risks factors that are contributing for accidents in Oil and Gas Exploration and Production Industry.
4. To Study the current methodologies of accident root cause analysis that the Oil and Gas industry adopted and suggest improved method.
5. To suggest the recommendations to overcome the problem.

1.5 RESEARCH METHODOLOGY

1.5.1 Theoretical framework –

There are several major theories concerning accident causation [31], each of which has some explanatory and predictive value. Oil & Gas industry also adopted the existing theories of accident occurring. However, over a period of time the occurrence of accidents were found to be not aligned with proposed theories. This could be interpret as the Oil & Gas operations are exposed to high degree of risks which are resulting in low probability and high impact incidents. Some of the theoretical models are listed below:

Simple Linear Models

It assumes that accidents are culmination of a series of events or circumstances which interact sequentially with each other in a liner fashion and thus accidents are preventable by eliminating one of the causes in the liner sequence.

Complex Linear Models

It is based on presumption that are a result of a combination of unsafe act and latent hazard conditions within the system which follow a liner path. Accidents could be prevented focused on strengthening barriers and defenses.

Complex-Non Linear Models

Accidents can be thought of as resulting from combination of mutually interacting variables which occur in real world environments and it is only through understanding the combination and interaction of these multiple factors that accidents can truly be understood and prevented.

Domino Theory

The Domino theory, also known as Heinrich's Domino theory, was developed by Herbert W. Heinrich in 1932. He is an engineer working for an insurance company in the USA in 1920's studied 75000 reports of accidents gained from insurance files and industrial records. In 1931, Heinrich first published Industrial Accident Prevention, a text based on his findings from the analysis of the accident reports. It is considered the first scientific approach to accident prevention. According to Heinrich, an "accident" is one factor in a sequence that may lead to an injury. The factors can be visualized as a series of dominoes standing on edge; when one falls, the linkage required for a chain reaction is completed. Each of the factors is dependent on the preceding factor.

According to the Domino theory, a person injury (the final domino) occurs only as a result of an accident. An accident occurs only as a result of a personal or mechanical hazard. Personal and mechanical hazards exist only through the fault of careless persons or poorly designed or improperly maintained equipment.

Faults of persons are inherited or acquired as a result of their social environment or acquired by ancestry. The environment is where and how a person was raised and educated. The factor preceding the accident (the unsafe act or the mechanical or physical hazard) should receive the most attention. The concept is pictorially represented as

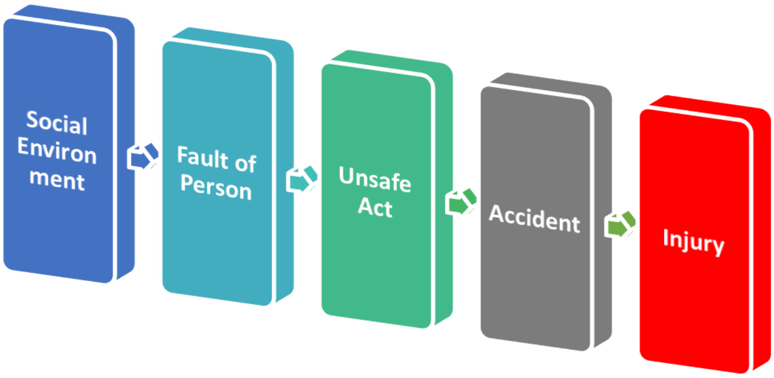


Figure 2: Domino Theory representation

Human Factors Theory

According to this theory, human error is the basic cause of the accidents. The main causes attributed are:

- Overload
- The work task is beyond the capability of the worker
- Environmental factors includes noise and distractions
- Internal factors includes personal problems and emotional stress
- Situational factors includes unclear instructions and risk level

1.5.2 Source of data

Data for this research study was collected from various sources

- International Oil and Gas Producers (IOGP) who globally bench mark the Health, Safety and Environment performance of the industry.
- Accident / incident data from Cairn India limited an Oil & Gas Exploration and production company, India.
- UK Health Safety Executive's publications (once in two months).

- OSHA (Occupational Safety and Health Administrative-USA)-Incident Rates of non-fatal occupational injuries and illness by industry and case types-2012.
- Various accident investigation reports published.
- Behavioural Safety Observations reports of Cairn India

1.5.3 Sampling

- Accident Analysis reports published in IOGP annual reports. These reports are based on benchmarking study contributed by 50+ major Oil & Gas companies in the worlds.
- Accident samples from Drilling, Exploration, Production Operations, Construction, brown field developmental activities of Oil & Gas.
- Detailed investigation reports of Cairn India, Barmer, Rajasthan an Oil & Gas Industry.
- Near-miss data and analysis reports of Cairn India, Barmer, Rajasthan operations.
- Questionnaire developed and responses obtained from safety professionals, line managers and leaders.
- Interaction with Injured personnel.

1.5.4 Statistical tools

- The result of the study with respect to accidents patterns compared with existing theories.
- Bow-tie-Xp tool used to identify the root causes of several accidents.
- BSCAT tool for analysing the failures of barriers in accident occurrence.
- Accident data comparison between IOGP and Cairn India, Indian Oil & Gas environment.

1.6 CONTENT OF THIS REPORT

The content of the thesis is structured in the following manner to achieve stated objectives of the research.

Chapter 1:

It deals with general introduction of research topics, its scope, objectives, over all research frameworks and research methodology.

Chapter 2:

It covers overview of accidents occurred in Oil and Gas Industry. The importance of Oil & Gas Industry in the business, the safety management system how it is important in considering and controlling various elements in accident occurring.

Chapter 3:

It deals with research Objectives focused on major accidents patterns in Oil & Gas activities, comparing the accident causations, inherent risk factors and current accident analysis models.

Chapter 4:

It illustrated the reviews made on existing literature in the similar field and allied field under various categories. It is focused on various disasters occurred and lessons learnt, human factors that are influencing the accidents in Oil & Gas and how the Organisations are dealing the problem.

Chapter 5:

It concludes the research with noticeable contributions in accident patterns in Oil and Gas (Upstream).

Chapter 6:

It includes References

Appendix is consolidated and given at the end for cross reference or verification purpose. The appendix includes definitions used in the thesis, two published papers and Curriculum Vitae of the scholar. This section concludes thesis report.

CHAPTER 2.
OVERVIEW OF ACCIDENTS IN OIL & GAS (UPSTREAM)

The chapter outlines the business importance of Oil & Gas, Major accidents that have caused human loss and environmental damages. It also illustrated the need of safety management systems that required to prevent disasters in Oil & Gas (Up-stream).

2.1 BUSINESS IMPORTANCE OF OIL & GAS INDUSTRY

Oil is wealth. For high quality of life, energy is the fundamental requirement. Oil is as important as agriculture to the developed world. It's truly a condition for the continued existence of most of the humanity today. For over hundred years, Oil is the primary contributor for the development of world economy. 2,5% of worlds GDP is directly contributed by Oil business.

The Oil and Gas industry is one of the most powerful business of world economy. More than four billion metric tons of oil is produced worldwide annually. Oil and Gas companies are among the largest corporations in the world. In 2015, Royal Dutch Shell reported a revenue of more than 250 billion U.S dollars. Oil demand and oil consumption have been rising steadily over the last decades and it is expected to increase further more till the year 2035.

2.2 MAJOR ACCIDENTS

Piper Alpha disaster was one of the worst offshore disasters and had huge impact on the oil & gas industry in the UK and subsequently the world. The public enquiry into incident report contained 106 recommendations and led to safety case requirement for each installation, requiring operators to demonstrate their ability to manage safety and emergencies as part of the Safety Management System etc.

The Deepwater Horizon drilling rig explosion occurred in the Gulf of Mexico, on the April 20, 2010 resulted in loss of 11 personnel and a significant environmental damage [15] [21]. This incident has been categorized as the largest environmental disaster in United States of America’s history as it spilled tons of Crude Oil.

According to the report developed by the NORA Oil and Gas Extraction Council, 648 workers were fatally injured in United States during year 2003-2008. It resulted in an occupational fatality rate of 29.1 deaths per 100,000 workers which is eight times higher than the rate for all United States workers. Nearly half of all fatal events in the Oil and Gas extraction industry resulted from highway crashes (29%) and workers struck by objects and equipment (20%). The illustrated incident data clearly emphasizes the need for an effective occupational safety and health management system that integrates safety and health concerns into a daily routine. People working in Oil and Gas industry are exposed to various risk factors.

2.3 PARADIGM SHIFT OF SAFETY MANAGEMENT SYSTEMS

Oil and Gas Industry works engage in many activities that exposes them to many serious hazards such as fire and explosion, falling from height, exposure to extreme weather conditions, unguarded machinery, being struck by heavy equipment, electrocutions and road transport hazards. Therefore to mitigate the risks and ensure safety of personnel an effective Safety management is essential.

The objective of occupational safety and health risk management is to identify and assess safety and health hazards existing at the workplace and to define appropriate control and retrieval steps.

Business processes in Oil and Gas industry are very complex. Hence it is essential that a systematized approach should be used for managing occupational safety and health hazards. Health, Safety & Environment Management is the key component for Oil and Gas' Safe and sustainable business [66].

Learning from the past incidents and to comply with regulatory requirements, the Oil & Gas companies have imbibed safety management systems in their business management. However, the reflection of repeated incidents reminds that the Organizations shall demonstrate a paradigm shift in their existing safety management system. It shall not only address the regulatory compliance but more on identification of work place hazards, risks of all types and demonstrate risk mitigation measures. The focus shall be on involvement of workforce, bringing a uniform safety culture for prevention of accidents. Safety needs to become the way of life for people in the Oil and Gas industry. A change of heart and a change of mind set are imperative to achieve Health, Safety and Environmental excellence.

Mere compliance with the standards and regulations in HSE is not enough. It is important for every Oil & Gas company to strive to benchmark and match the global best practices and improve continuously.

Small initiatives such as daily toolbox talk before the commencement of work can go a long way in adoption of HSE at grass root levels in the organization.

In countries such as Japan, workforce is trained to be alert through regular yoga sessions. Both, mind and body have to be alert and work in coordination in order to prevent any hazard from occurring.

Organization to believe, Health, Safety and Environment management saves both the loss of lives and disruption/damage to infrastructure which is imperative to move the wheels of prosperity.

The Oil & Gas industry often focuses on the financial risks that is facing and neglects the other risks in pursuit of commercial profits. While achieving business targets is important, it must be remembered that safety cannot be compromised. Having a big expansion agenda is welcome but the growth should be sustainable and inclusive.

The leadership team across organizations would be the key to leading this paradigm shift in transforming HSE culture, making business processes state-of-the-art, safe, and sustainable.

It is also essential to have a good reporting culture among the organizations in the industry. Incident reporting and information dissemination is extremely important. Any such matter that is not reported represents a missed learning opportunity to analyze the root causes of the incident which in turn can help prevent such incidents in future.

Good Health, Safety and Environment (HSE) Leadership does not happen by chance. Everybody has to play a part in the same. This includes the contractors, service providers, employees and the organization leadership who have the ultimate responsibility.

HSE needs to be built in the design phase itself as at that phase it is possible to eliminate some hazards rather than just controlling them later.

Effective major hazards control requires constant engagement of the workforce and contractors. The leadership needs to regularly monitor and evaluate the performance of the organization. Openness about sharing performance data and key lessons from all major incidents as well as near-misses is critical.

Any leadership program must engage the workforce to ensure they receive, understand and react appropriately to leadership messages. Leadership programs must also engage the workforce since they have a unique understanding of how work is actually done in practice. Involving the workforce is an essential source of data about how work is actually done and how plant is operated. Leaders must tap into this vital source of intelligence about their business if they are to manage major hazard risk effectively.

An organization needs to cultivate a chronic sense of uneasiness about "Building Human into HSE Management System".

Workforce engagement is a collective behavior and is required to deliver world class safety performance. At all levels within the organizations, people need to exhibit correct behaviours to reinforce and support workforce engagement. The quality of interactions between people is critical and decides the team's effectiveness

While the Process Safety Management (PSM) system is very powerful, it fails to prevent major losses due to the lacking human elements. Behavioral safety and cultures still remains the weakest link. The PSM system if implemented as per current standards is not sufficient in addressing prevention of major incidents. The lacking elements in PSM include employee participation, competency, behavior based safety (BBS) and human factors. With human factors, there is a need for a more "softer" human factors management sciences approach rather than just a human factors engineering approach. Human factors need to be considered when developing systems and procedures, something which is not being done effectively. There is a strong need for integration of BBS and PSM. Further debate and discussion is required to establish the new elements that must be weaved in to the PSM system.

HSE management is at a major transformation point. It is changing from compliance driven command & control model (regulations, standards, corporate policies) to stakeholder market-based model (reduced operation risk, enhanced corporate brand, and increased shareholder value). There are many operational and enterprise challenges to this transformation. There are many business benefits such as reduction in insurance costs, increased productivity and reduction in maintenance costs when such challenges to this transformation are met.

The use of predictive analytics is emerging as an important technique to identify organizational, operational and safety risk factors and is becoming core to their performance management programs. Predictive analytics is about analyzing current transactional and historical facts to make predictions about future events. It is the ability to model good (or safe) operations learned from historical experience and then apply those patterns to avoid future events. It is a natural progression of increasingly sophisticated tools available in safety management and has become more common in the chemicals and petroleum industry in such areas as predictive maintenance. Predictive HSE analytics is driven by data. The goal of the predictive analytics is to draw reliable conclusions from data captured across the enterprise and act accordingly.

Oil and Gas Organizations to realize that safety is an investment that organization makes to sustain itself but not a cost.

CHAPTER 3.
RESEARCH OBJECTIVES

The chapter outlines the outcome of various objective of the study focusing on accident patterns, factors leading for the accidents, various accident causation models and its interpretation, influence of human factors in accidents.

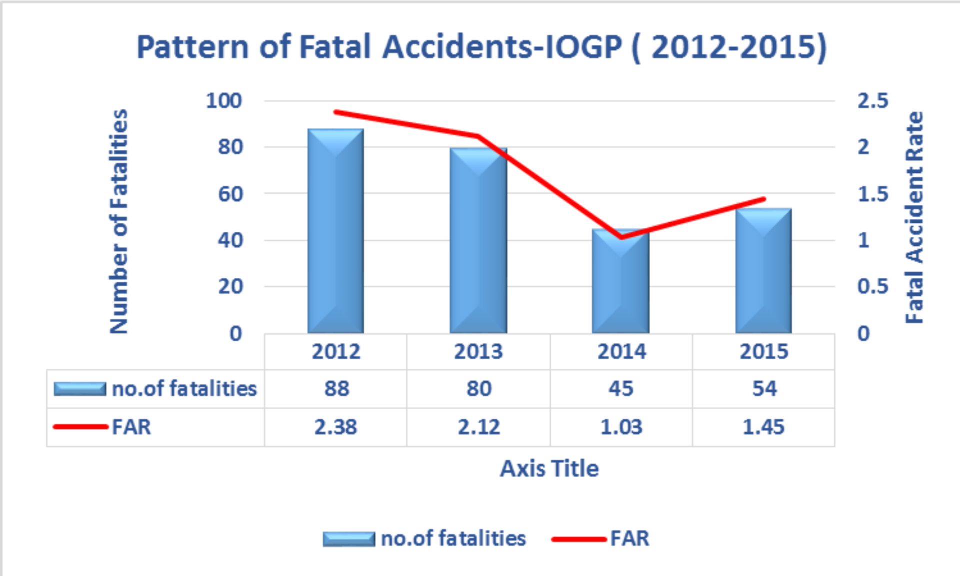
There were total five objectives of the study which are discussed in details

3.1 TO CARRYOUT RESEARCH IN IDENTIFYING THE PATTERN OF ACCIDENTS OCCURRED IN OIL AND GAS FIELDS

Benchmarking reports published by International Oil & Gas Producers (IOGP) were reviewed. Four Years accident and incident data, the patterns of accidents in Oil & Gas (upstream) were focused [37-38]. During the year 2014, there was about 51% reduction in fatal accident rate. It is further reported that 78% of fatal accidents would have been averted by following lifesaving rules. These lifesaving rules are directly related to human attitudes and work place safety behaviours.

These rules are significantly supported by behavioural changes and timely interventions. The pattern of fatal accident rates is represented in Graph #01

The data covers 52 companies of IOGP spread over 111 countries.
(Ref: IOGP-Safety performance indicators – 2014 data, Report 2014S)



Graph 1: Pattern of fatal accident rates as per IOGP

More than 5000 injuries including fatalities and lost work day cases were studied. (Source: IOGP Safety performance benchmarking data for the years 2012, 2013, 2014 and 2015)

	FATAL ACCIDENT STATISTICS-IOGP (2012, 2013, 2014 & 2015)				
	2012	2013	2014	2015	Total
FATAL	88	80	45	54	267
LTI	1699	1627	1518	1032	4844
				Total	5876
WORKDAYS LOST	53335	45772	45527	36913	

Table 1: Fatal Accidents Statistics

Analysis of the 45 fatal incident descriptions shown that at least 78% of the fatal incidents reported in 2014 related human behaviours (Ref: IOGP Report 459).

There are a number of common causal factors appeared consistently in the top ten for both fatal incidents and high potential events for each of the past five years.

- Organizational: Inadequate training/competence
- Inattention/lack of awareness: Improper decision making or lack of judgment
- Organizational: Inadequate work standards/ procedures
- Organizational: Inadequate supervision
- Organizational: Inadequate hazard identification or risk assessment.
- More than 60% of the injuries in Oil and gas occur to the hand. Moving parts of the machinery and manual material handling are the causes of hand and finger injury. Fall from height, caught between and struck by are also major concern of injury.

3.1.1 MAJOR INCIDENTS IN OIL & GAS- CASE HISTORIES AND LESSONS LEARNT

25 Major Incidents were studied and incidents involving more than 10 fatalities are summarized in Table#02.

Date	Rig Name	Location	Fatalities	Incident
01/12/1956	Qatar#01	Arabian Gulf	20	Sinking
30/06/1964	CP Baker	Gulf of Mexico	22	Blowout
15/04/1976	Ocean	Gulf of Mexico	13	Sinking
02/10/1980	Ron	Saudi Arabia	19	Blowout
15/02/1982	Ocean	North Atlantic	84	Sinking
03/03/1983	Nowruz	Persian Gulf	20	Fire

25/10/1983	Glomar Java	South China Sea	81	Sinking
16/08/1984	Enchova	Brazil	37	Blowout
06/07/1988	Piper Alpha	UK. CS	167	Fire
03/11/1989	Sea Crest	Gulf of Thailand	91	Sinking
15/08/1991	DB29	South China Sea	22	Sinking
10/08/1996	Ubit Platform	Nigeria	18	Fire
20/03/2001	Petrobras	Brazil	11	Sinking
27/07/2005	Bombay High	Indian Ocean	22	Fire

Table 2: Major incidents occurred in Oil & Gas

Few cases were illustrated with the root causes of the incident.

Piper Alpha

Figure 3: Piper Alpha before the incident	**Figure 4: Piper Alpha after the incident**
	

A series of major explosions and fires have occurred on the Piper Alpha Oil platform located in the North Sea approximately 100 miles from Aberdeen, Scotland on July 6, 1988. At the time of the disaster 226 people were on board. The disaster impacted the lives of 165 personnel and destroyed the platform totally. As per Lord Cullen report [66] on "*The Public Inquiry into the Piper Alpha Disaster* , the most likely causes are: a release of light hydrocarbon (condensate; i.e., propane, butane, and pentane) occurred when a pump was restarted after maintenance. A non-standard blind was installed in the piping flange after removal of a relief valve (RV) in the pump discharge for its service. When subsequent shift personnel restarted the pump, the loosely installed flange allowed the release of huge flammable hydrocarbon cloud, which subsequently found an ignition source.

Many other Oil and gas operating platforms were inter connected with Piper Alpha platform as network operations. The interconnected platforms continued their supply of Oil to Piper Platform as the manager failed to recognise the bigger risk and take a decision to shut down their platforms.

A series of explosions further occurred and the gas riser pipeline became weak due intense heat from the fire. This has hampered the rescue operations.

Failure of work permit system fundamentally contributed for the incident occurrence. Two separate work permits, one for the pump repair and another for testing the RV have been issued. As the RV job was completed by the end of the shift it was decided to close the work permit for that day. However this change in job status was not communicated to the operations team. When the subsequent operations shift personnel started the pump under maintenance caused the hydrocarbon release.

Piper Alphas deluge was unavailable at the time of the incident as the diesel-powered fire pumps are in manual control mode due to the presence of divers in the water around the platform.

The was no fireproofing on structural steel of the Piper Alpha and hence the platform lost its structural integrity within 15 minutes.

The emergency preparedness and training given to the personnel on the Piper Alpha platform was inadequate.

Basic human errors and spiral of barriers failure in the system lead to disaster.

Macondo Incident:

On April 20, 2010, a massive explosion and fire resulted when hydrocarbons escaped from Macondo well while a well control event failure occurred (Ref: Fig# 5).

Eleven people lost their lives, and 17 others were injured. The fire continued for 36 hours until the rig sank. For 87 days, Hydrocarbons continued to flow from the reservoir through the wellbore and the blowout preventer (BOP) resulting in a spill of national significance.

The root causes illustrated are:

The hydrocarbons were not isolated by the annulus cement barrier.
The cement had been pumped down the production casing and up into the wellbore annulus to prevent hydrocarbons from entering the wellbore from the reservoir. The annulus cement which was light nitrified foam cement slurry was placed across the main hydrocarbon zone. Hydrocarbons entered the wellbore annulus probably due to nitrogen breakout. Failure of quality assurance, risk assessment and weaknesses in cement design and testing were the caused concluded by the investigation team.

Isolation of hydrocarbons was failed by the shoe track barriers.

The investigation team concluded that hydrocarbon ingress was through the shoe track, rather than through a failure in the production casing itself or up the wellbore annulus and through the casing hanger seal assembly.

Without well integrity the negative-pressure test was accepted.

The rig crew failed to recognize the influx and did not act to control the well until hydrocarbons had passed through the BOP and into the riser.

Well control response actions failed to regain control of the well.

Diversion to the mud gas separator resulted in gas venting onto the rig.
The fire and gas system failed to prevent hydrocarbon ignition. Hydrocarbons migrated beyond areas on Deepwater Horizon where the potential for ignition was higher.
The BOP emergency mode did not seal the well.

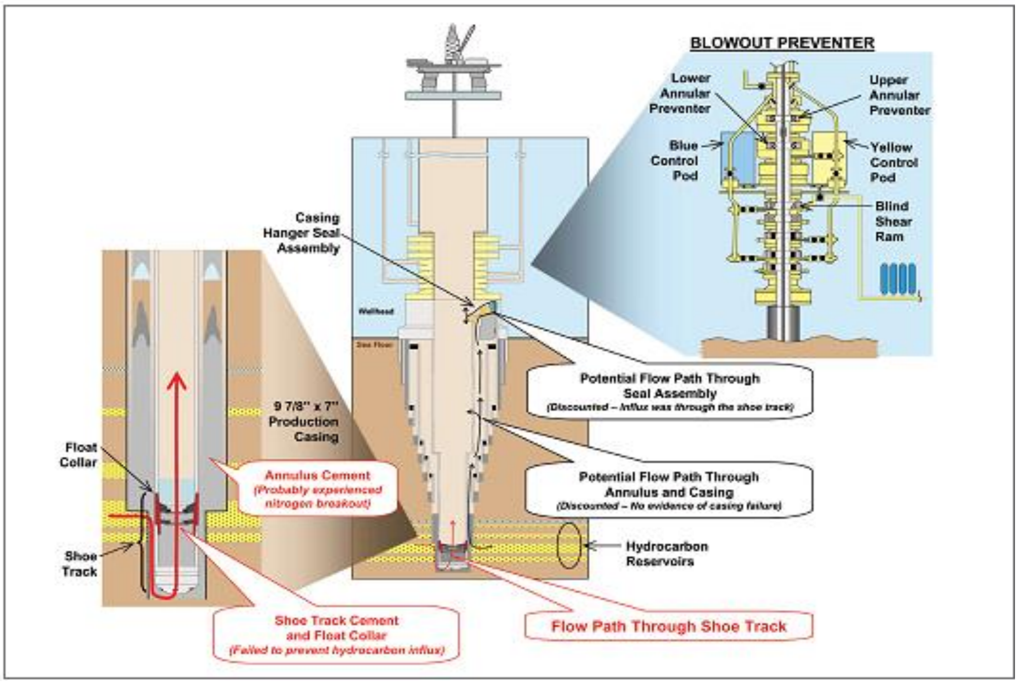


Figure 5: Macondo Well Schematic

A series of barrier failures lead to the major disaster.

Bombay High North (BHN) Disaster

Figure 6: BHN Platform before the Incident.	Figure 7: BHN platform after the incident
	

On July 27th 2005, the Samundra Suraksha, a multipurpose support vessel, was working in the Mumbai High field completing a diving support campaign. Although owned by ONGC, the 100m long vessel was operated by the Shipping Company of India (SCI).

At approximately 1400hrs, a cook in the galley of the Samundra Suraksha cut off the tips of two of his fingers. For medical treatment, it was decided to shift the injured to the land. Weather conditions on the day of the event were unfavourable. The injured person was successfully transferred to the platform. As the Samundra Suraksha moved away from the platform, it experienced a large heave from ongoing ocean swells and the thrusters were unable to compensate. The helideck of the vessel struck one or more of the export gas lift risers.

It resulted in gas leak which got ignited and flames spread rapidly to adjacent risers with no fire protection.

The rapid spread of the flames also hindered rescue operations, as only a small portion of lifeboats and rafts could be launched. Over a 15-hour period, 362 of the 384 POB that day were rescued, along with 11 pronounced dead and 11 lost at sea. Rescue operations were also severely affected by weather conditions, as the monsoon had grounded all helicopters in the area for several days. The Samundra Suraksha MSV caught fire due to several explosions.

The incident highlighted the basic design failure of protecting the gas raiser from unexpected collisions.

Blowout explosion of C.P. Baker Drilling Barge

The blowout explosion of C.P.Baker Drilling Barge happened on 30th June 1964, located at the Gulf of Mexico. 8 people lost their life, 13 gone missing (presumed dead) and 22 people were injured in the incident.
It is one of the first major offshore disasters in the world among many other blowouts.

C.P. Baker was a catamaran-type drilling barge. The two sixty feet long hulls were joined by a steel framework, on top of which were a drilling package situated aft, a pipe deck midships and a helideck in the forward area. Two cranes were also on board, located on the outboard edge of each hull and eight anchors were used to keep the vessel in position. On the night of the accident, two support vessels were moored next to the C.P.Baker.

The crew of the C.P. Baker began drilling its twenty-second well since being constructed: with the proposed 10000 ft. deep well. The first indication of anything amiss was a ‘bubbling’, ‘boiling’ or ‘geysering’ action of the water between the two hulls of the catamaran, together with a ‘trembling’ of the vessel. The geysering effect increased until the water was striking the bottom of the drill platform with great force and cascading back to the hulls of the vessel. Water entered the hulls through the open doors on the main deck. Electric power was soon lost, and crew members, realizing that a blowout was occurring, attempted to rouse the other members of the two boats moored alongside and the rest who are sleeping in the forward position of the C.P.Baker. Shortly thereafter, a massive explosion followed by fire encompassed the C.P. Baker and the two service vessels alongside.

Crew members of the C.P.Baker abandoned the vessel by jumping over board. Most of the survivors left the vessel by the port bow. The C.P. Baker sank before the last survivors had been rescued. Gas continued to erupt and burn for approximately 13 hours after the C.P. Baker sank.

Globally about 345 offshore blowouts have happened from 1957-1992. One of the risks of the blowout is oil spills. Even with modern technology and modern safety measures, spills are a part of the offshore oil and gas industry. Oil spills and blowouts have been affecting on marine aspects especially on marine habitats.

Conclusions drawn from the above incident are:

- Accidents in Oil and Gas industry have a big impact on human safety and Mother Nature.
- Accidents and incidents could be prevented through ensuring competency of the workforce and periodic training programs.
- The Hazard identification techniques and hazard analysis techniques are most important in the prevention of serious accidents in Oil and Gas industry.

Pasarlapudi Blow Out

It was the largest blowout ever recorded in the history of the India's oil and natural gas exploration with a fire that engulfed drilling a site. The fire continued for 65 days. The blowout did not cause any casualties, but the drilling rig was destroyed. Damages to the drilling rig were estimated at INR 9.2 crore as well as about INR 7 crore of damage to equipment at the well site area.

It has caused major impact on the local inhabitants, destroying crops, especially the coconut trees and paddy fields. A sudden increase in gas pressure and the casing was pushed out with the result the well caught fire. Initially for about 30 days there was a vertical spread of flame and later fire in the horizontal direction. Seven villages within the 2 kilometres radius of the rig, approximately 1,500 people were evacuated immediately.

As the researcher belongs to this region, he visited the incident site. It was a disaster in the area known for natural greenery, paddy fields and densely populated with coconut trees. The incident has effected the surrounding area with high noise, heat and disturbed the common man life for more than 60 days.

The villagers of Pasarlapudi were evacuated to a safe place. The restoration of cultivation in the affected areas was delayed by almost one season, thus affecting the livelihood of many marginal farmers. Indirect loss due to the blowout was much higher. The villagers were affected by the chronic noise pollution caused by the hissing sound of the gushing gas at high speed. The flames and increased noises are felt about 25 kms away from the incident site.
The noise pollution was in the range of 100 to 140 decibels close to the well site to 55 decibels (normal) around 2km radius.

The images of the Pasarlapudi blowout:

Figure 8: Pasarlapudi Rig on Fire	**Figure 9: Pasarlapudi Blowout Scenario**
	
Figure 10: Pasarlapudi Blowout-Effect on Environment	
	

3.1.2 ACCIDENT ANALYSIS OF IOGP AND INFERENCES

- About 50 Oil & Gas companies participate in the benchmarking study consistently.
- More than 1500 and 1000 incidents have been reported in the year 2014 and 2015 respectively.
- More than 600 work place injuries including fatal accidents, disabling injuries and High potential events reported during 2014 by IOGP were reviewed for the current study.
- Also about 700 work place injuries for the year 2015 reported by IOGP were reviewed for the current study.
- The pattern of accident occurring, causes for accidents are analysed and significant cases discussed below.

Table 3 : Pattern of Accidents and their causes (IOGP incidents)

Incident	What Went Wrong	Causal Factors
Tunisia (Oct 7 2014): A contract driller drilling shot holes for a seismic acquisition contractor was fatally injured when a hooded sweater he was wearing became entangled in the rotating drill string.	Failure to recognize hooded clothing as a potential loose clothing hazard. The drilling machine lacked barriers to protect operators from rotating machinery	Improper position (in line of fire)
Australia (May 19 2014): A fatal incident had occurred at the fabrication site for the construction of Turret Project involving a rope access. A worker 27 years old Indian national found unconscious inside the 900 mm diameter Riser Guide. Failed to recognise hazards and failed to ensure safety controls for Confined space work.	Permit to work was authorized and issued without Job Safety Analysis having taken place for high-risk confined space entry activity. Suitable rescue equipment for confined space entry not available at site location. No pre-entry gas test immediately before entry into confined space.	Inadequate Hazard Identification and risk assessment Failure to warn Hazard Inadequate work standards/ procedures
Malaysia (Mar 13 2014): A contractor personnel fell from a permanent working platform about 6 m high whilst conducting inspection on a grating replacement job. Injured person pronounced dead on arrival by the attending Doctor.	Non-compliance to PTW Poor grating replacement work planning and execution Inadequate working at height training	Improper position-line of Fire Inadequate guards

China (Aug 23 2014): One driller was fixing a latch cylinder on a top drive side-shifting device, on one platform in China, The driller was hit by a piston rod when it ejected from the latch cylinder and a hammer. The driller lost his balance and fell to the drilling floor and died.	The injured did not wear safety harness or other fall protection equipment. Energy is not isolated	Servicing of energized equipment/inadequate energy isolation
Malaysia (Feb 4 2014): Operations was rigging down a Mud Return hose which was suspended by two chain blocks secured to a platform overboard A-frame. Two workers were in the process of disconnecting the chain blocks from the Mud Return Hose, so that the hose could be recovered by the crane. One chain block was released, whilst the other one was jammed. While they were still working on it, the jammed chain block's sprocket suddenly ruptured releasing an array of projectiles, which struck both workers. One worker sustained fatal injuries while the other hand injury.	Poor leadership and risk-taking working environment Non- compliance to safe lifting practices Ineffective inspection/maintenance system	Improper position (in the line of fire) Improper lifting or loading Inadequate maintenance/inspection/testing
Germany (Sept 23 2014): During workover of an Oil well	Failure of risk assessment Non-compliance to safe	Line of fire

in the oil field vented gas ignited and set the well surface and workover unit under fire. One worker severely burnt and died	work procedures	
UK (Sep 4 2014) -A contractor scaffolder fell from an offshore installation in the North Sea to the sea through an open section of deck grating, which had been barriered off when an appropriately sized and constructed scaffold barrier. The scaffolder sustained fatal injury	The scaffold barrier was breached by the scaffolder	Non-compliance to basic safety rules
Russia (Oct 22 2014) : During well construction works, when the mud pump for well washing was started up, the welded plug tore off from the quick-split joint of the manifold force line. A contractor employee suffered a fatal injury to the abdomen by the element of the damaged plug.	Contractor employee made changes to the design of the manifold stanchion without issuing permits. The driller continued the drilling process knowing that unauthorized plugs were used on the rig and unauthorized tapping into the manifold stanchion was done.	Inadequate maintenance procedures Not complied with management of change process
Turkey (Sep 30 2014) : While trying to break out one cross-over from Drill pipe, pipe joint was pulled-up to bring it forward to the iron roughneck. The elevator arm made contact	No standard Operating Procedure (SOP) No reporting on previous similar bumping against mast structure	Improper position – line of fire Failure to warn hazard

with mast beam and swung toward the V-door, hitting two IPs: One fatality and one severely injured.		
USA (Nov 15 2014): The drilling crew was making up stands of pipe in the mouse hole. As the second joint in the string was being made-up, the third joint was simultaneously being pushed up the pipe delivery system to the rig floor level. The joint was pushed too far up the delivery system and past its equilibrium point resulting in the top of joint falling unrestrained to the rig floor. The joint struck the contractor in the torso area causing him to fall backwards and to strike the back of his head on the manual tongs located on the rig floor. The workmen died.	Failed to recognize safety issues ignored or overlooked hazards	Improper position-line of fire
Mexico (22 2014): Offshore Rig in the Gulf of Mexico-Gas leak during cementing of the well. Later, after catching a burning point, an explosion occurred in the drilling floor, causing fatal injuries to two employees and one contractor	Procedures not considering drilling alignment connection risks. Flaws during tightness tests. Inadequate enforcement of basic safety procedures. Lack of supervision, late gas leakage detection and	Inadequate use of safety systems Lack of attention Inadequate barriers

	mitigation	
Brazil (Mar 26 2014): When getting off the walkway to the bottom floor of the vessel, the employee fell from the ladder, hitting the floor with his head and suffered traumatic brain injury.	Tripped on the step by using strip type sandals Fell from the ladder due to sudden illness.	Fitness of the employee Use of PPE
Congo (Nov 17 2014): A marine expert contractor involved in platform refuelling. Once the refuelling came to an end, while relocating the hose in its seat with the assistance of a crane operator, the hose was released due to the failure of the suspending fibre rope. The hose coupling hit the victim at the head which resulted in fatal injury.	Struck by the hose coupling.	Improper position or line of fire
Malaysia (Oct 26 2014): A crawler crane boom and surrounding area were struck by lightning during lifting activities. IP was standing nearby the work area and fatally injured.	Poor job planning Inadequate protective barriers	Improper position – line of fire. Inadequate work standards.
Myanmar (Mar 20 2014): One employee working on a crane barge, went into the sea, without life jacket. Resulted in drowning, fatal incident.	Lack of understanding the risk, failure to use PPE	Violation of safety procedures PPE

Indonesia (May 18 2014): One support vessel collided with a tanker causing fatality.	Under investigation	
Romania (Sep 28 2014): An electrician went to check a malfunction of well. He also went to the substation pole. When he opened a pad lock. Once on the platform, the victim was in dead zone and electrocuted as a result of arc-blast.	Victim was in hurry, under self-imposed pressure and distracted, which did not allow him to properly assess the risks.	Violation of safe work procedures. Failure of safety barriers.
Qatar (Jun 12 2014): When truck driver at unsafe speed and aggressive driving behaviour, he collided with trailer moving inform of the truck resulted him with fatal injury.	Over speeding and lack of attention. Careless driving attitude.	Violation of procedure.
Canada (Jun 19 2014): IP struck by skid mounted load during truck loading activity resulted in a fatal injury.	Under investigation	Line of fire.
Mexico (Jun 16 2014): A worker without training was operating a crane causing a crash of the cab and fatal injury.	Inappropriate operation of a crane without the training and permit to work.	Procedure violations intentionally. Lack of awareness.
Mexico (Jan 3 2014): A repair, consisting of change a production line segment, which had broken during a well	Struck by: A poor job safety analysis, non-compliance with procedures, poor	Improper position (line of fire)

fracturing job caused a fatal injury to a worker was when he moved into the path of the pipeline.	supervision of operations.	
Mexico (Apr 29 2014): A contractor personnel fatal accident occurred during construction work on a road accessing a well drilling area. The machinery driver reversed the truck and did not see the worker causing death.	In attention while reversing machinery, lack of caution to distract the deceased worker.	Improper position (line of fire)
USA (Feb 11 2014): A sudden gas release which occurred on the wellhead, resulted in a serious fire, one contractor fatality.	A loss of containment event on a gas wellhead resulted in a serious fire and a fatality.	Lack of procedures.
USA (Mar 22 2014): The right of way for a future pipeline was being cleared and a worker was struck by a tree and fatally injured. The worker cutting the tree was fatally injured when struck by part of adjacent damaged tree.	Inadequate Risk Assessment prior to the activity. Failed to recognise and address the safety risk with the adjacent tree. Ignored or overlooked hazards.	Improper position-line of fire.
Mexico (Jul 21 2014): A derrick man suffered an incident during the manoeuvre to move five steel plates, weighing approximately 2 tons with the support of crew, which consisted of three people. They	No adequate precautions and inadequate follow-up procedures available. Simultaneous operations should be analysed and properly performed.	Violation of safe work procedure. Improper position (line of fire).

had removed and were holding the plates because the crane was receiving material from a board. During the manoeuvre the worker was caught between the plates and a wall.		
Mexico (Feb 11 2014): During the process of dismantling the modular light super beam, been lifted by the crane, the welded support of the crane welded to the structure failed and the crane itself, a high power unit and the IP fell into the water.	No adequate precautions and inadequate follow-up procedures. Simultaneous operations should be analysed and properly performed.	Inadequate protective barriers.
Argentina (Apr 4 2014): During the vent-line laying works, the Drill-collars (DCs) position in the racks interfered with the work that was carried out. The crew decided to use the forklift to move the DCs. The forklift was positioned and the crew moved out from the operations area. Suddenly, one of them came back to the operations area to remove a rope that was used to level the vent-line interfering the DCs movement. At the same moment, the operator positioned between the DCs,	Violation unintentional	Violation of Safety procedure. Improper position (in the line of fire).

the pipes moved and the operator was captured between DCs.		
Brazil (Sep 16 2014-Drilling): During the removal of stabilizer of drilling column, the torque of the connection to the top tube was broken. The connection to the down tube was unscrewed from the rest remained trapped column in the rotary table. Using Catarina probe, assembly, stabilizer the top tube was positioned vertically on the table rotating (the probe platform). After it was manually unscrewed from the upper tube, the stabilizer was kept in vertical position by floor men team for installation of lifting cap and further handling. Installed the lifting cap in an attempt to connect the auxiliary winch at the helm, the stabilizer lost its balance and fell, hitting two floor men. One of them died.	The column switching procedure not detailed the withdrawing tool task. The risks identified in the procedure and meeting pre task have not been properly evaluated and treated. The stabilizer was held in vertical position by the physical effort of four employees, unsupported load handling equipment or mechanical barriers to prevent it from tipping.	Inadequate standards. Inadequate training and competence.
Colombia (Feb 1 2014-Drilling): On a carousel rig, one 5” joint dropped from pneumatic	Hazards not evaluated	Failure to identify hazards before start of the job.

elevators down the V door to the pipe rack, hitting two roustabouts working close to catwalk: one fatality. Elevators accidentally opened by third party operator while trying to move the joystick box with the elevators loaded.		
Gabon (Apr 22 2015): On a laterite (dirt) road, rollover of a light utility vehicle, the passenger was ejected and struck under the vehicle.	Personnel not authorized to use the vehicle, over-speed, dirty road, and passenger not wearing his safety belt.	Violation of procedure.
Nigeria (Nov 22 2015): During the repair work on an 8" illegal connection on a 28" pipeline, a sudden surge of crude oil and gas occurred impacting on personnel. Four personnel died.	Sudden pressure release	Failure to identify the hazards.
Gabon (Jan 18 2015): A modular mobile crane was installed on a platform to perform the five year maintenance of the fixed platform crane. The mobile modular crane was inspected for the commissioning. While being load tested at 3t the mobile crane base assembly failed and caused the structure	During the fabrication of the crane, a spacer plate was added to correct a defect in the machining of one part, resulting in decrease of screw penetration and modification of the effort type applied on the screws. General failure of the quality control. No	Inadequate work standards. Inadequate hazard identification or risk assessment.

to collapse backward and hit the crane operator who subsequently died.	specific risk assessment for crane test.	
Pakistan –Exploration (Aug 20 2015) A cable helper employed by the seismic contractor fell approximately 6 metres from a rock path into a gorge and was fatally injured. The injured person along with others was assigned to recover the cable and geophones from a seismic shoot.	The terrain assessment and classification failed to identify a hazardous location. Ineffective supervision of work moving in rough loose path.	
Pakistan-Production (Oct 22 2015): A low energy explosion occurred with a road tanker reversing to the temporary crude loading bay. Four personnel lost their lives due to burn injuries.	The initial blast was followed by a higher energy explosion after 25 seconds, creating a fireball and static fires of minor crude oil spills. Simultaneous operations not coordinated, no HSE plan.	Failure to identify hazards and risk assessment. Violation of safe work procedures
Germany-Production (Sep 2 2015): While preparing a temporary gas condensate vessel for cleaning and inspection work an explosion occurred inside the 20m3 vessel. This event resulted in a fatality of one person and injuries of three	A flammable atmosphere developed due to evaporation of remaining gas-condensate inside the tank. The ignition of the flammable atmosphere was caused by heat from a pyrophoric iron sulphide	Not following the procedure. Improper position-line of fire. Inadequate work standards. Inadequate hazard identification or risk assessment.

people who were standing too close to the radiant heat and flying debris.	chemical reason The task was assumed to be routine. Therefore the risk awareness was limited.	
Romania-Drilling (Feb 25 2015) A mechanic climbed on the truck to get a chain sling using the steps on the side board of the truck and grabbed the BOP wheel. He slipped on the step and gripped the BOP wheel for balance. The BOP weighing 350kg toppled over the edge of the truck platform and fell on him resulting in death.	Safe access to platform and securing of loads not recognized as major risk.	Failed to secure material.
UK-Construction (Feb 28 2015) While installation of a 130 ton crane, the crane driver had to move on the trailer side, on a narrow passage. He fell from height impacting his head against the trailer. He died.	The design of new crane trucks trailer has a narrow passage to go from the cabin to the rear cabinet. The hand rails are very elevated so difficult to grab.	Improper position-line of fire. Inadequate guards.
Russia-Production (March 19 2015) While the examination of the pump jack in order to find out the source of the noise the	The cleaning of the equipment was done on the working pump jack. The barrier did not limit the access to the dangerous	Procedure Violation. Not followed protective methods.

operator went inside the barrier of the tank gear of the pump jack and was caught between the crank gear and frame of the pump jack.	zone. The operator opened the barrier door and entered the unsafe zone.	
Russia-Drilling (May 22 2015) During a loss of well control event the wrong procedure for the well ceiling was used that caused a spark and ignition. Two contract workers got burnt and died.	While shift change the information on the status of the well condition and works were not transferred properly. The night shift was not informed about the displacement of the liquid without the gas from the well. The night shift did not have experience with the well or the location of the shut off wall. So, when the well control was lost the crew took the measures on the well ceiling which caused the spark and ignition.	Violation of safety procedures. Failure to warn of hazard.
Russia-Construction (Nov 21 2015) While construction works of the overhead power lines the electrician confused the line under the construction without the power with the working line under the power. He climbed on the working line pole and started working on it and was	There were no warning signs, no barriers to indicate the working zone and separate the unsafe zone.	Failure to follow safety procedures. Servicing of energized equipment. Failure to warn of hazard.

electrocuted.		
Kuwait-Drilling (Feb 11 2015) While setting casing slips in E-section of the well head section the contractor engineer observed the casing slip does not fit the well head section due to off-centre of the casing in the well head. Several attempts were made to centre the casing and to install the slips through various means for e.g. pulling the casing at rig floor level, pulling and rocking the blowout preventer but were unsuccessful. Finally it was decided to simultaneously shake BOP stack using a fork lift and web slings joined by shackles to give jerks and hoisting the BOP by hoist. In the process of doing this activity, the web sling attached to the fork lift carriage parted, resulting in the whipping of the shackle along with other web sling to strike the victim on his head, who was positioned at the edge of cellar gratin of BOP. The strong hit by the shackle resulted in severe injury to the head leading to skull fracture	Bad condition of the web sling. No proper inspection/certification of sling. Excessive and shock loading of sling exceeding its safe working load capacity. Absence of a standard procedure to align an off-centre casing in the well heads. Failure to access the risk involved in the centring position. The location of the contractor engineer in 'line of fire'	Improper position-line of fire. Lack of judgement. Inadequate hazard identification or risk assessment.

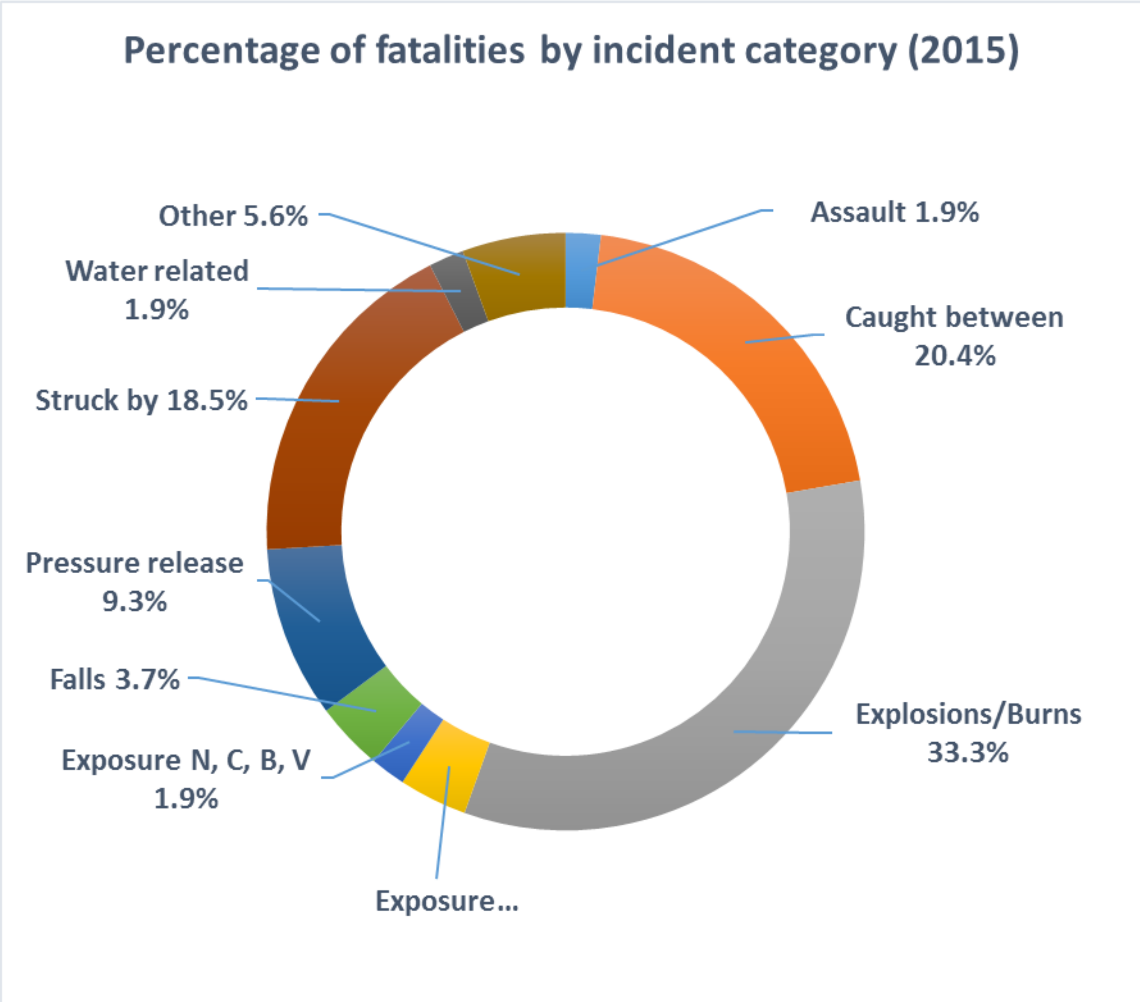
and subsequent death.		
Kuwait-Drilling (July 25 2015) BOP was lifted using trollies for casing slip setting and hook load was released. Job was planned for cut casing and nipple down BOP to carry out top-up job to fill casing annulus. Casing cutting job was carried out by rig welder who was positioned on a ladder placed inside cellar pit. Welder started cutting the final part of the casing by keeping one foot on the ladder and other foot on the horizontally laid barrel inside the cellar. Upon completion of cutting the last section circumference of casing, due to the imbalance of BOP, it swung towards the welder and stuck on his head which got caught in between the cellar and the BOP adaptor flange, causing fatality.	Casing cutting was started and BOP inclination was not considered. Welder moved to the BOP location (hazardous spot) and started cutting the final part of the casing by keeping one foot on the ladder and other foot on the horizontally laid barrel inside the cellar.	Improper position-in line of fire. Failure to follow lifting or loading procedure. Failure to warn of hazard.
UAE-Drilling (June 25 2015) A floor man was stuck by a winch line that was under tension and got suddenly released when a lead sheave failed the crew was in the	The lead sheave failed releasing the wire rope. The deceased was standing in the line of fire. The rig crew continued laying down HWDP instead of	Improper position-line of fire. Servicing energized equipment.

process of laying down a joint of HWDP (heavy weight drilling pipe) with the use of rig floor tuggers. 1 tugger suspended the joint, while the second tugger was secured to the Samson post on one side of the V-door and lead through a lead sheave, which was fixed to the Samson post, on other side of V-door. The tugger wire was being used to pull the joint of the HWDP to the V-door when the lead sheave failed under load.	waiting for the crane.	
USA-Production (April 18, 2015) Contractor employee was working on flare header when a compressor injected air into a plug inserted into pipe. It was ejected, striking the contractor employee, resulted in fatality.	Over pressurization occurred and the plug was ejected under high pressure striking the individual. There was no confirmation that pressure being applied was venting to prevent the over-pressurization of the flare line.	Improper decision making or lack of judgement.
Mexico-Production (Feb 5, 2015) During activities and performing movements with a crane, making a turn a worker was caught against supporter pipe, causing a severe brain	Misapplication of procedure.	Failure to follow the procedure.

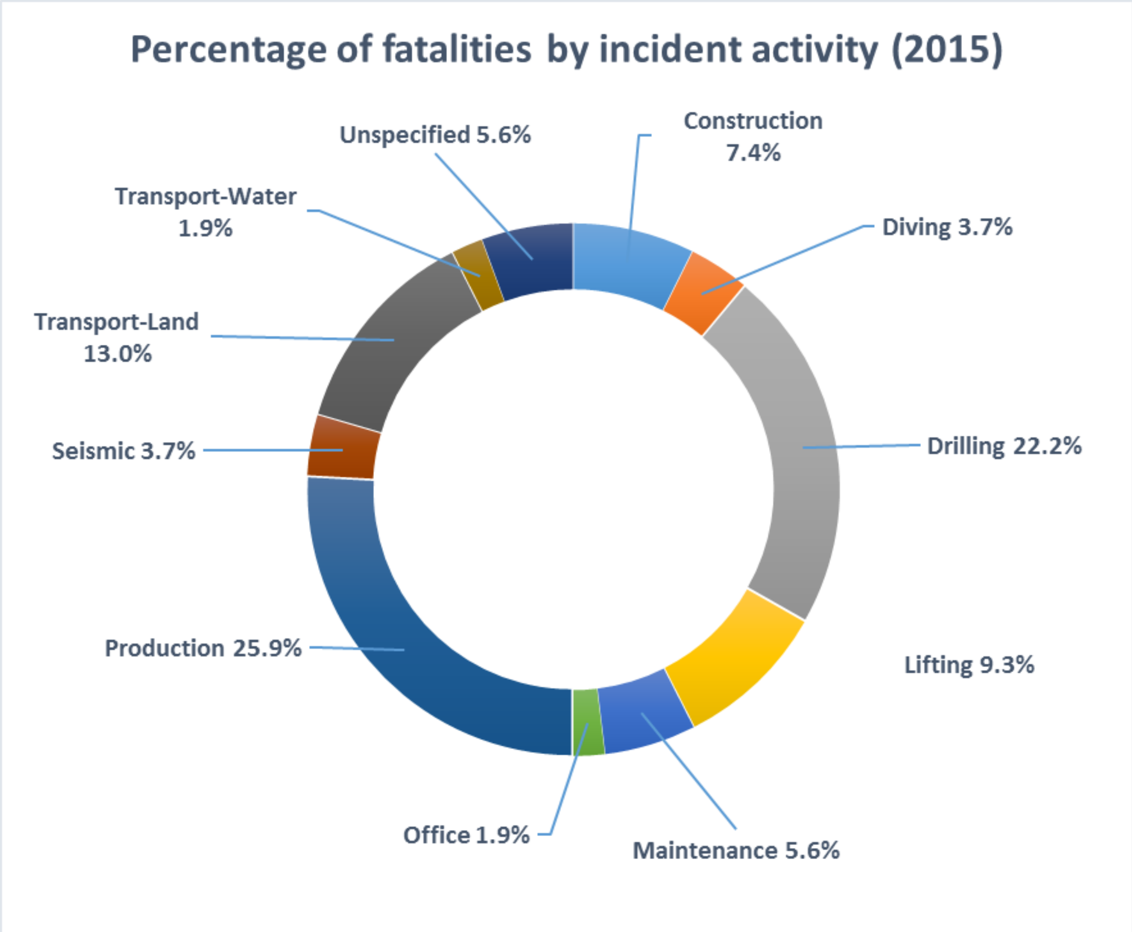
damage.		
Mexico-Production (Sep 30, 2015) A worker was trapped by a rack containing oxyacetylene tanks when resting in a hammock placed between the rack and storage tank of 1000 litres of water.	Misapplication of procedure. Lack of knowledge on hazards.	
Mexico-Production (Aug 26, 2015) During cutting of an angle using acetylene, flame occurred due to presence of oily water in the vicinity of the area.	Presence of hydrocarbon on the floor. Poor housekeeping.	Failure to follow procedure. Failure to identify hazards.
Mexico-Drilling (July 27, 2015) At a marine platform, during activities of intervening a well, a contractor workman was involved in removing the pipelines. He stayed inside a metal box when a winch approx-100kg fell down from a height of 6 metres. It resulted in fatality.	Misapplication of procedure.	Failure to identify hazards.
USA-Drilling (Oct 20, 2015) In preparation for a jetting operation of 36-inch conductor a drill pipe stand was being	Inadequate instruction, the spotter (IP) was identified to be their first day in the new role. Inadequate	Failed to secure the equipment. Inadequate communication.

handled by the pipe racking system. The bottom of the drill pipe stand swung free from the pipe racking system and struck the individual in the head resulted in fatal injury.	identification and evaluation of loss exposure. The potential hazard for stored energy to be accumulated in a stand on this way had not been recognized.	
Argentina – drilling – (March 25, 2015) While a winch truck was removing a tubular-carrier structure from the site, an employee from the contractor company was struck between the front bumper of the vehicle and said structure.	Decision to perform a front operation with a fastening chain, the driver failed to ensure that the helper was standing outside the line of fire. The helper positioned himself in the line of fire.	Improper position-in line of fire. Improper lifting or loading. Inadequate training or competency.

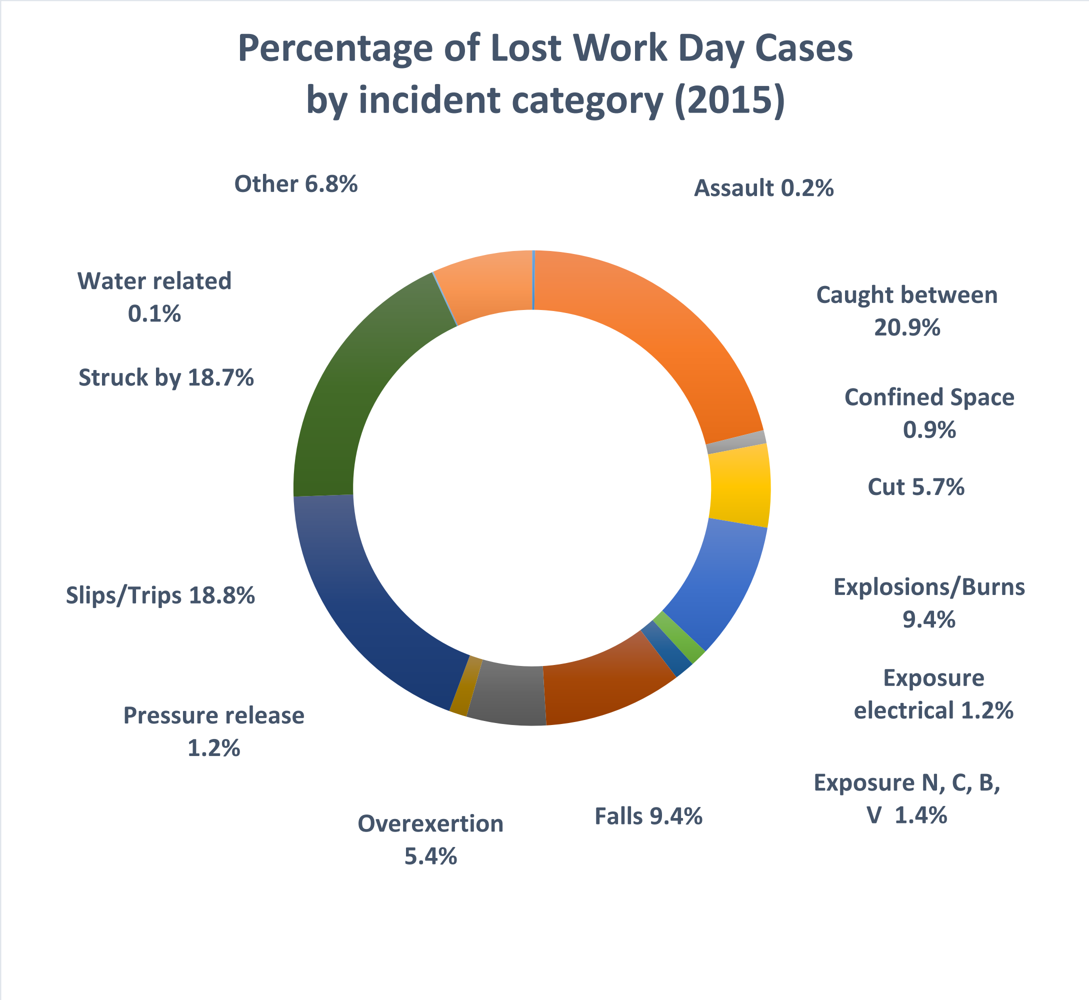
Graph 2: Accident analysis (IOGP) and its interpretations:



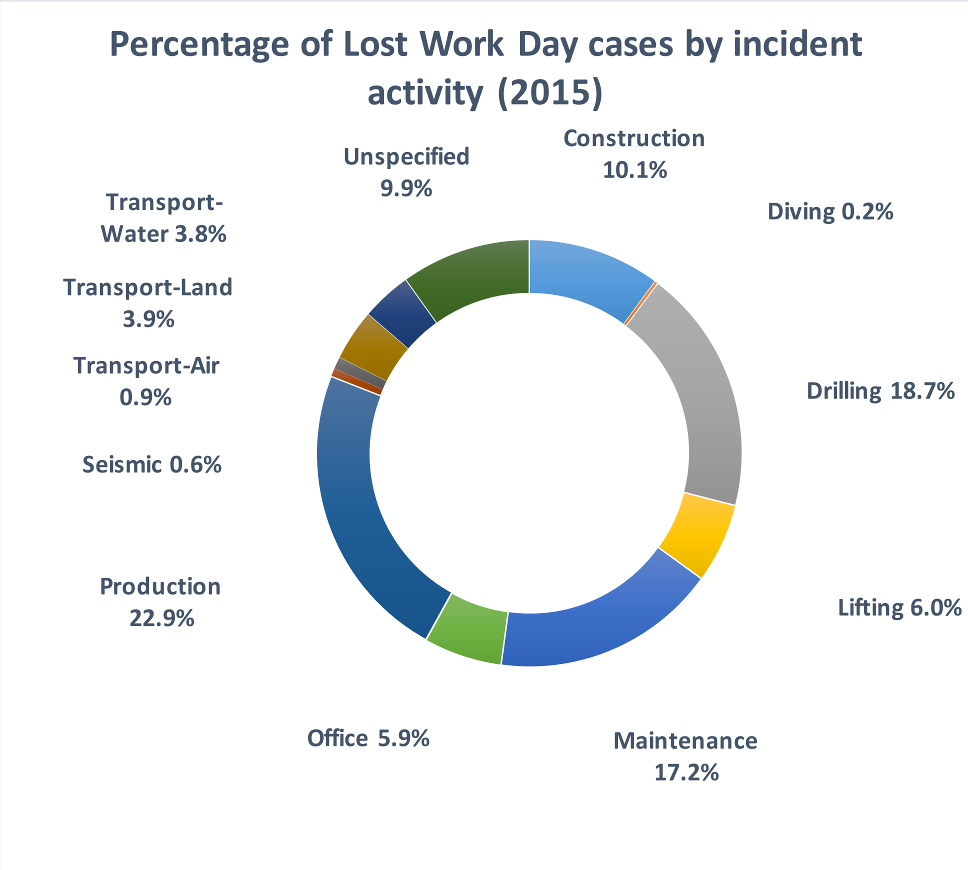
Graph 3: Percentage of Fatalities by incident category



Graph 4: Percentage of Fatalities by incident activity (2015)



Graph 5: Percentage of Lost Work Day Cases by Incident Category



Graph 6: Lost Work Day by incident Category (2015)

3.1.3 INFLUENCE OF WORK PATTERNS ON ACCIDENT OCCURRING

Oil and Gas Operations are supported with shift working pattern for achieving its efficient business excellence. The typical shift durations (total time in one stretch) may be 14 or 21 days. It includes continuous 7 day and 7 night shifts. Over the defined shifts, often extended hours of work to be performed by the work site personnel. The shift pattern varies from operator to operator and also depend on type of work like maintenance, production operation and support services.

Therefore the irregular shift patterns and extended work hours have shown significant health effects on the personnel working in Oil and Gas operations. It is having inherent risk factors on accident occurring.

Several researchers have described the effect of fatigue on individual's performance and significant contribution to accidents. It is observed that micro sleeps are unaware by the individuals at work place. It is a high risk of individuals expose to work place injuries. Decreased performance due to fatigue has been identified as one of the root causes in major disasters such as Exxon, Valdez, Three Mile Island, Bhopal and Chernobyl. Though these disasters are from other industries, it is having almost similar reason for serious accident to occur in Oil and Gas Operations.

Parkes et.al described in their studies that the rate of serious injuries in night shift is more significant than the day shift. When personnel work in prolonged shifts (beyond their normal shift timings) or work extended days (beyond their allocated shift days) shows risk of increased severity of injury. Many work place studies on fatigue provided evidence of increased injury specifically from within the North Sea Offshore environment.

Lauridsen and Tonnersen, (1990) have described in their study that there is an increased injury rate during the night shift. Collins et.al in their review found significant evidence that rotating shift schedules affect alertness and performance.

There is concern that errors may increase towards the end of 12 hrs shift. In addition, it has been demonstrated that older workers fare less well on 12 hrs shifts.

There have been significant reviews on the health effects of personnel working at North Sea Oil and Gas facilities particularly in general shift work and night work. No adverse overall effect on mortality has been reported. The most consistent health effects appear to be in the areas of gastrointestinal disease, sleep disturbance and cardiovascular disease.

Indian Oil and Gas industry also operates different shift work patterns. Adjusting to extreme climatic conditions for personnel of drilling, exploration and operations is a significant challenge. The maximum temperature of 50 degrees and above at Northern parts of India where in the recent past exploration and drilling activities have shown moderate risk of accidents.

Fall of objects, pinch hazards and fatigue have contributed for more number of serious work place injuries in Northern Indian Exploration and Drilling activities. Hand and finger injuries, fractures, and work place illness were significantly reported.

To have uniform shift patterns and more assured work place safety, major Oil and Gas industry partners have approached the Government of India. Accordingly, in India labour ministry has notified changes in the Mines Act of 1952 exempting persons employed in exploration and production of oil and gas mines from a mandatory eight hour work day and a weekly off.

However, the workers will not be deployed for more than 12 hours of any one day and 21 days at a stretch, along with an equal number of rest days. The move is a big relaxation for oil and gas companies that routinely depute such workers to offshore rigs or at remote onshore locations and do not find it feasible to follow the defined work hours under the labour laws.

According to the notification, the workers deployed for the 21 days “on-and-off” work pattern will be provided with accommodation and welfare amenities including free boarding and lodging, free transportation facility, free medical facilities as well as recreation options. Employers will also be expected to pay overtime or extra wages to these workers.

The Oil and Gas facilities who adapted a specific risk assessment while deploying shift personnel have achieved reduction of work place injuries in India.

3.1.4 TOP TEN ATTRIBUTES OF ACCIDENT CAUSATION - ACCORDING TO FIELD PERSONNEL ON ACCIDENTS OCCURRING IN OIL & GAS

A specific survey form has been designed objectively and circulated to field personnel of Oil & Gas upstream facility operations. 376 such feed backs have been received and analyzed. The survey form composed with 15 elements covering the basic understanding of Heinrich theory of accident occurring, relevance to Oil & Gas, significance of root cause analysis, importance of safety barriers in prevention of accident occurring.

Field safety personnel, line managers, group managers, contractor representatives, work site supervisors, graduate engineers have participated in the survey. The samples were obtained from India, Aberdeen UK, Canada, Kuwait, Saudi Arabia, Qatar Petroleum, Bahrain and UAE.

The following is the "Accident causation Survey" feedback form:

Table 4: Accident Causation Survey form

Accident Causation Survey form						
Requested by : Siva Prasad Penkey, Research Scholar						
Survey Inputs provided by: **Experience:** **Age:**						
Sno	**Survey Element**	**Rating**				
		1	**2**	**3**	**4**	**5**
1	Do you agree accidents are caused, just not happen					
2	Do you agree all accidents are preventable					
3	Heinrich theory of accident occurring is true for all accidents (1:29:300)					
4	Have you observed any deviation of Heinrich theory of accident Occurring in your Organization when you have analyzed the incidents					
5	Is failure of barrier cause of accident Occurring					
6	Is failure to identify Hazards at work place and ensuring Risk Controls, the causes of accidents					
7	Are always root causes identified for accidents occurred in your Organization					
8	Are the root cause analysis techniques used are adequate and personnel competent to do it					
9	Do you agree that pattern of accidents are different for different work environment as nature of hazards changes					

10	Is the lack of competent job supervision one of the root cause for the accidents						
11	Is the lack of management consistent commitment one of the root cause for recurrence of accidents						
12	Do you agree failure to comply with standard Operating procedure (SOP) cause of accident occurring						
13	Do you agree learning from lessons and implementing the recommendations prevent recurrence of accidents?						
14	Do you agree there is a direct relation between worker attitude and accident occurring						
15	Do you agree consistent persuasion in bringing safety behavioural change will reduce work place injuries						

Legend	
1	Total Disagreement (0-20%)
2	Somewhat not agreeing (20-40%)
3	Agreeing (40 -60%)
4	Agreeing to great extent (60-80%)
5	Fully agreeing (80-100%)

Analysis of Survey Results:

Accident Causation Survey-Analysis						
Sno	Survey Element	Rating				
		1	2	3	4	5
1	Do you agree accidents are caused, just not happen	30	55	95	135	61
2	Do you agree all accidents are preventable	30	57	75	144	70
3	Heinrich theory of accident occurring is true for all accidents (1:29:300)	98	125	75	66	12
4	Have you observed any deviation of Heinrich theory of accident Occurring in your Organisation when you have analysed the incidents	50	50	101	154	21
5	Is failure of barrier cause of accident Occurring	45	40	65	155	71
6	Is failure to identify Hazards at work place and ensuring Risk Controls, the causes of accidents	26	50	50	130	120
7	Are always root causes identified for accidents occurred in your Organisation	103	110	111	25	27
8	Are the root cause analysis techniques used are adequate and personnel competent to do it	98	110	99	40	29
9	Do you agree that pattern of accidents are different for different work environment as nature of hazards changes	49	34	75	137	81
10	Is the lack of competent job supervision one of the root cause for the accidents	36	52	67	145	76
11	Is the lack of management consistent commitment one of the root cause for recurrence of accidents	25	20	50	130	151
12	Do you agree failure to comply with standard Operating procedure (SOP) cause of accident occurring	47	33	146	71	79
13	Do you agree learning from lessons and implementing the recommendations prevent recurrence of accidents.	22	35	85	112	122
14	Do you agree there is a direct relation between worker attitude and accident occurring	27	32	92	104	121
15	Do you agree consistent persuasion in bringing safety behavioural change will reduce work place injuries	32	30	83	140	91

Table 5 : Accident Causation Survey Analysis

- More than 80% personnel agreed that all accidents are preventable.
- Heinrich theory of accident occurring is not fully satisfying the causation of accident occurring in Oil & Gas.
- More than 81% personnel agreed that barriers are very important to prevention of accident occurring.
- More than 73% personnel agreed that failure to identifying the hazards and ensuring risk controls are the cause of the accident occurring.
- About 68% personnel have expressed that inadequate root cause analysis or lack of skills are the deficiencies of identifying the accident occurring.
- More than 85% personnel agreed that hazards are different for different work situation.
- More than 68% of personnel agreed that lack leadership and supervision is the cause of accident and its recurrence.
- More than 90% of personnel agreed that failure to comply with Standard Operating procedures and implementing lessons learnt are the underlining causes of accidents.
- More than 89% of personnel expressed that attitude of work force is having direct relation with accident occurring and behavioural changes may reduce the accidents.

RESULT

- Failure of safety barriers leading to disasters in Oil & Gas.
- Heinrich theory of accident occurring is not fully satisfying the causation of accident occurring in Oil & Gas (Up-stream) activities.
- Failure to identify the hazards and ensuring controls are the significant causes for the accident occurring in Oil & Gas.
- Behavioural safety and sustainable safety cultures are still the weakest link.
- Attitude of work force is having direct relation with accident occurring and behavioural changes may reduce the accidents.

3.1 COMPARE THE ACCIDENT CAUSATIONS OF CAIRN INDIA WITH OTHER ACCIDENT CAUSATION MODELS TO IDENTIFY SIMILARITIES OR GAPS.

3.2.1 About Cairn India

Cairn India, an Oil & Gas Exploration and Production company located at Barmer district of Rajasthan, India.

Cairn India is the largest independent Oil and Gas exploration and production company in India with a market capitalization of US$ 7 billion and the largest private sector producer of crude oil in India. Cairn India operates 27% of India's domestic crude oil production.

The Mangala Oil fields in Barmer, Rajasthan, discovered in January 2004, is the largest onshore oil discovery in India in more than two decades. Mangala, Bhagyam and Aishwariya fields-major discoveries in Rajasthan block have gross ultimate Oil recovery of over 1 billion barrels.

Cairn India was rated as the fastest-growing energy company in the world, as per the 2012 and 2013 Platts Top 250 Global Energy Company rankings.

Cairn aspires to a zero-harm environment for personnel at work. It has engaged 20000 work force in peak time of constructing well-pads, Mangala processing terminal and other associated facilities. These work force comprises unskilled, semiskilled and highly technical from various states of India and also rest of the world. The harsh climatic conditions were one of the work place Health and safety challenges. With continuous efforts, Cairn has established a strong Health, Safety and Environmental management systems engaging the workforce. As a result, it has bagged several recognitions from national and International level. It has focused to create safe work environment and recognized to bring awareness on significance of near-misses, its reporting, analysing and corrective actions. It has encouraged the employees and contractors to report near-misses through periodic training programs, tool-box talks, supervisor responsibility, contractor engagement process and mass communication methods, the personnel who reported significant near-misses were recognized at highest level which motivated individual to be proactive always.

Cairn Facilities at Glance:

Figure 11: Ravva Facility-RD-7

Figure 12: Ravva Facility-RC-5

Figure 13: Mangala Facility

Figure 14: Pipeline facility-Storage tanks

3.2.2 Accident Analysis of Cairn India

- Cairn has established Incident reporting and analysis mechanism (CIMS) across the Origination.

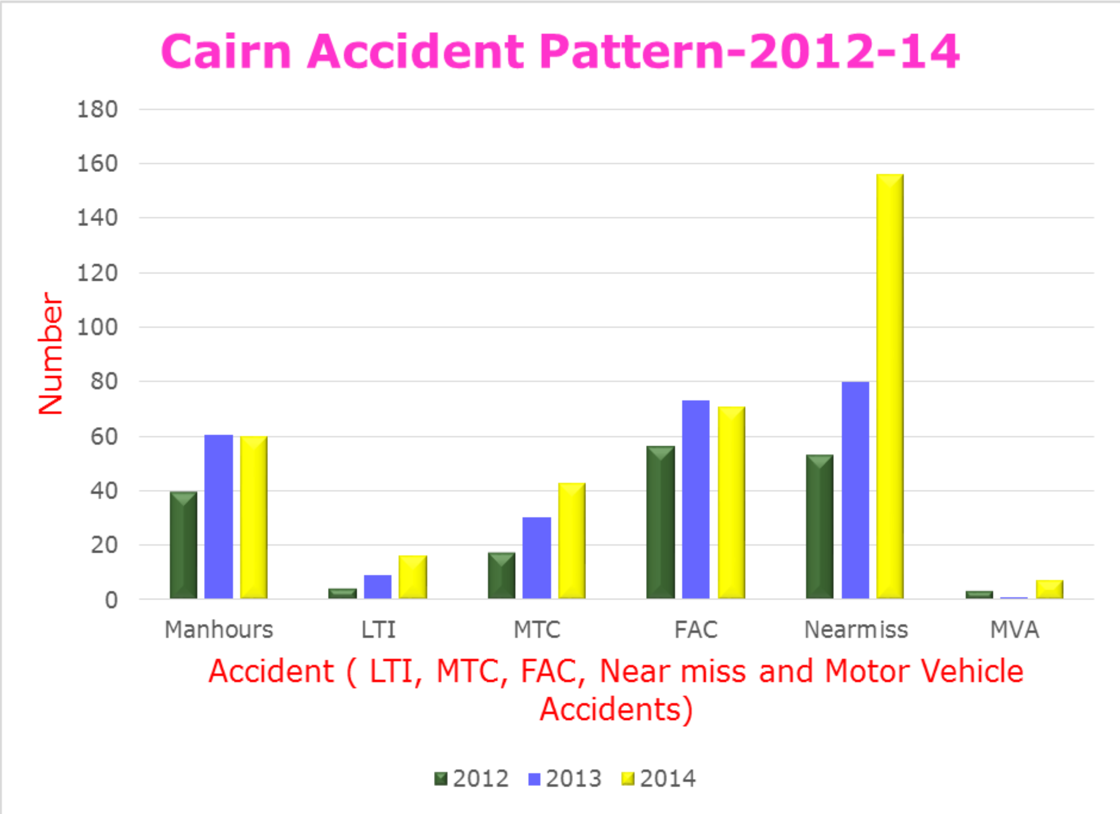
- Incidents including Fatal, Lost time, Lost Work Day cases, Medical treatment cases, First-aid cases, Nearmis and safety behavioral observations are reported through this system.

- During the year 2012, 2013 and 2014 the company has clocked man-hours as 39.4, 60.63 and 60.2 respectively.

- A total of 2533 relevant incidents reported during the years 2012, 2013 and 2014 have been considered for the current study.

- Out of the above 619 Health and Safety incidents during 2012, 2013 and 2014 including Fatal, Lost time, Lost Work Day cases, Medical treatment cases, First-aid cases from the above are considered for further analysis.

- All the incidents have been analyzed and interpretations are graphically represented



Graph 7: Cairn Accident Pattern (2012-2014)

The incidents that have caused at Cairn India were also analyzed. The following are the extracts from few incidents patterns of brief root causes.

Table 6: Incidents at Cairn India

Incident	What Went Wrong	Causal Factors
While a welder carrying out root pass, a heavy pipe slipped and fell on him. He died as he was crushed below the pipe	Failure of job coordination between two groups working on the same job lead to move the heavy pipe from the other while welding is in progress No Job safety analysis Poor communication	Failure to identify the hazards Failure of site work supervision
While adjusting a stack of marble floor tiles, the load suddenly fell on the workmen crushing him under the tiles. He was injured fatally.	The heavy marble piles were not supported The material handling methods failed Line of fire	Line of fire Failure to identify the hazards and root causes
On 08 December 2013, riggers were rearranging the pipes from its stacking. While a rigger trying to catch the tag line inadvertently stacked pipes rolled over. The rigger got trapped between the pipes and received fracture to his both legs.	No established safe working methods for stacking handling of pipes	.Line of Fire A competent job supervisor was not present at work site to supervise the job. The regular supervisor passed on the job to crew and he also left the job site. Therefore, the total activity

		exposed to a risk of no safety control resulted into serious fracture injury.
While installation of riser work was under progress, IP was approaching BOP control panel of rig floor. He lost his balance as his right ankle got twisted and fell on rig floor. He received fracture to his left forearm.	Uneven rig floors Gratings not in good condition	Failure to identify the hazards and root causes
Roustabout (Injured Person with help of other roustabouts was unloading chemical bags from trailer. As the bags are in torn condition It was decided that the bags will be unloaded by deploying a Hydra and a Forklift carrying an empty jumbo bag wherein the Carbo-Prop bags will be placed such that to avoid any spillage. While adjusting the bags hanger, the fork lifts fork came down on IP and struck the right hand which was resting on the trailer. His Right Hand middle finger received a crush injury on impact with the fork.	The IP was adjusting the straps of jumbo bag on forks while forklift was in operation. IP failed to recognize the pinch hazard The forklift's forks were placed below the trailer bed which made the IP to insert his hand between trailer bed and the fork lift.(to adjust the bag straps) Line of sight was missed by the forklift operator (he was unable to see what exactly happening at the trailer side). Hence he was totally depending on crews verbal / signal	Line of fire Failure of job supervision Job knowledge Failure of Communication between two groups *The scholar was one of the accident investigator and the zest of the investigation is presented below.

	communication. The crew were not familiar with rigging signals	
Dismantling of stand pipe manifold was in progress. While releasing the hammer union connection from last thread by hand, it got released from thread. Due to sudden swing, it hit IP's rt. thumb causing contusion injury.		Pinch hazard Failure to identify the hazard
On 16.11.14, batch Mixer movement was in progress. As the electrical cables are obstructing the mixer vehicle movement, the helper of the vehicle lifted the overhead electrical cable with an unidentified object so that the trailer could pass. The OH line lifted was a 440 V energized line. Another 11 KV OH line was crossing perpendicular and above to the line being lifted, had a 'safety net' The IP got electric shock and electric flashover due to heavy fault current at spot and body position of IP in the arc flash zone, when the lifted OH line got in touch with the safety net. Subsequently his clothes got fire resulting in burn injuries.	Use of sub-standard tool and wrong body position, close to the electric arc flash zone (nearest body part of IP was approx. 1.9 meters from the lifted energized OH line) resulting in electric arc flash and electrocution. No positive isolation (shutdown) was carried out for the lifted OH line prior to the trailer passed below , resulting in arc flash when IPs body position was in proximity of arc flash zone	Inadequate Leadership Assessment and review of route survey for Raag #S4 to ABH #3 prior to movement of trailer with batch mixer was not available for this route. Hazards and Control measures not clearly documented or communicated to transport crew (driver and helper (IP)) in absence of route survey for this route.

The IP fell on ground, He received deep burn injuries.		
Floor men slipped and fell from Monkey board. Due to safety harness in position, as it was holding him, he was in hanging position at 20 feet below monkey board. He received deep cut injury on his forehead and fracture on cervical vertebrae. (C-5 & C-6)	Fall from height on drill rig	Failure to secure
While IP was stepping down from support vessel to work boat, his feet got crushed between them. He received injury on toe and other fingers.	Fall from height	Lack of Attentiveness
When IP opened the cap of Radiator of Air Compressor, Hot water splashed on his right arm and some part of chest. It has caused 2nd degree of burn.	Unsafe work procedures	Violating basic safety rules Lack of supervision

A disabling Injury case of Fingers crushed between a fork lift's forks and a trailer bed while unloading catalyst bags.

The Scholar was one of the accident investigation committee member and involved in analysing the root causes, interaction with the injured and provided recommendations to prevent the recurrence.

On 18th March'2013 around 1005hrs, Mr. Masharam (age 25 years), Roustabout (Injured Person) with help of other roustabouts was unloading Carbo-prop (chemical powder) bags from a trailer.

As a bag was found torn, the crew decided to transfer the chemical in an empty jumbo bag by deploying a Hydra and a Forklift to avoid any spillage. The newly appointed supervisor (first day of the job) instructed the roustabouts, forklift driver and hydra operator to continue the work and left the place.

One of the roustabout voluntarily started coordinating and giving signals. The injured person (IP) was standing near the trailer with his hand resting on the hook of the trailer. The hydra picked up the jumbo bag from trailer and was trying to put in the empty jumbo bag which the forklift was carrying. During this process, the fork of the forklift was slide below the trailer bed and then was signalled to move up the straps of empty bag. Due to blind spot in front, the fork lift driver could not see the position of IP's hand and also could not hear signal man's voice due to noise of forklift engine. In this process, IP's fingers caught in between the hook of trailer bed and fork of forklift. While removing the hand, his Right Hand middle finger received a crush injury on impact with the fork.

IP was given First aid treatment at the site and then shifted to a general surgeon in nearby town. He was then referred to an orthopaedic surgeon at other city, where fractured was confirmed on X-ray. However, the orthopaedic surgeon noticed development of sign of gangrene and referred the IP to a plastic / vascular surgeon at higher centre (Bhavnagar, ~ 100kms from that place). The plastic surgeon operated on his finger for ~4 hours.

An accident investigation using Bow-tie analysis of

“Finger crush injury-while unloading catalysis bags.*

Bow Tie Analysis

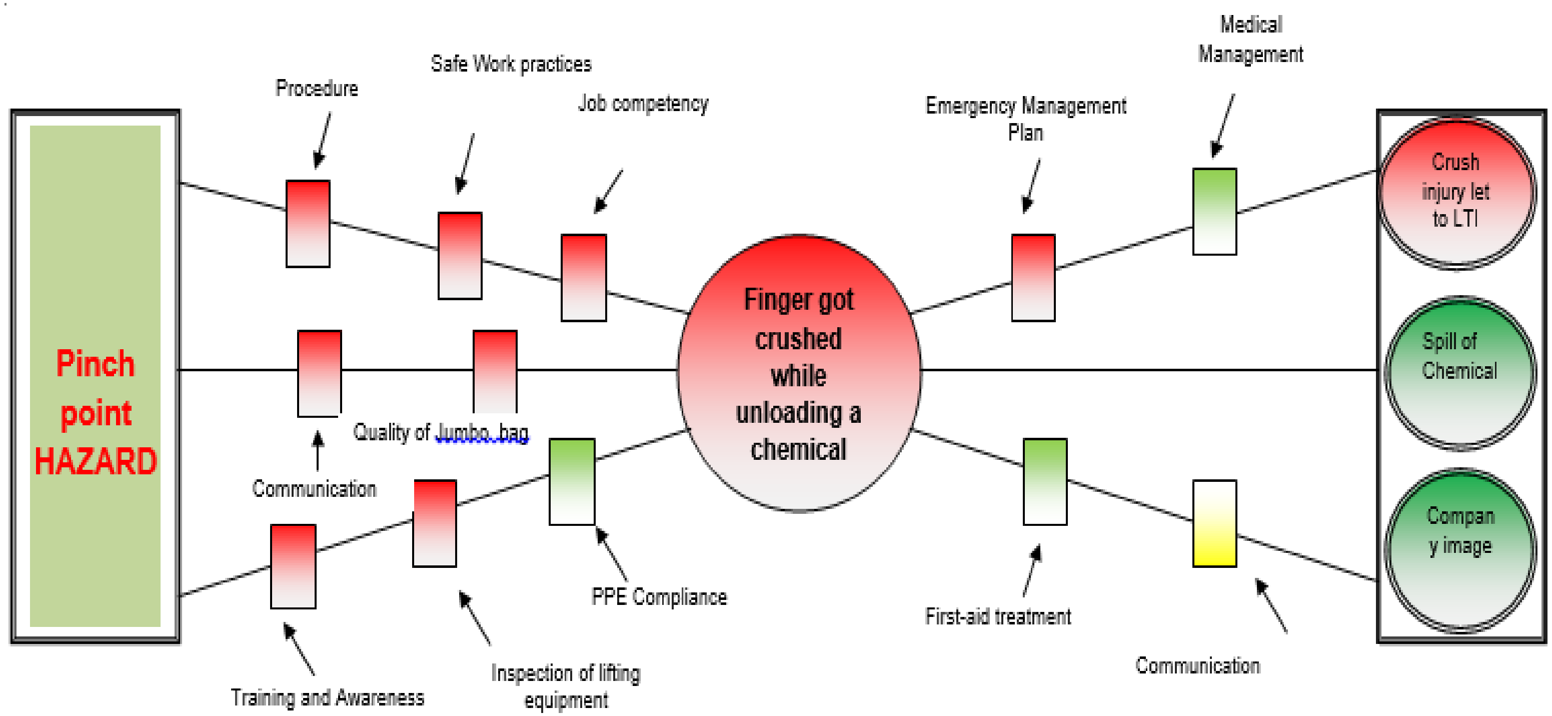


Figure 15: Bowtie- Pictorial representation of Case Study

Figure 16: Injured Person recuperating at hospital

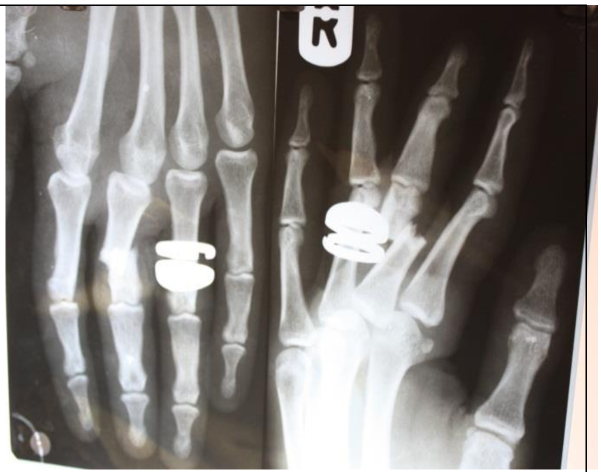


Figure 17: X-ray of Injured Finger showing fracture

Figure 18: Injured finger with dressing partially removed (dorsal view)

Figure 19: Injured finger

The disabling case of finger crash

Root Cause: Absence of supervisor at the work location during the abnormal conditions

A disabling Injury case of contractor worker's leg fracture when stacked pipes rolled over at storage yard.

The Scholar was one of the accident investigation committee member and involved in analysing the root causes, interaction with the injured and provided recommendations to prevent the recurrence.

On 08 December, 2013 around 1100 hrs Pipe restacking was under progress by means of a mobile crane. Pipes from a small lot which was lying closer to the fencing area was being restacked a little farther away from the fence onto hardened surface for safer storage. After shifting and resting one length pipe on the stack, the riggers on each side loosened the pipe clamp from both ends. While releasing the pipe clamp, one side of the clamp (along with lifting belt attached) got stuck between the two rows of pipe. The rigger then got between the pipe rows to loosen and release the pipe clamp. While doing so, a few pipes of the smaller lot rolled from the stack trapping the Rigger's legs between pipes.

The investigation team has interviewed various personnel involved directly and indirectly in the incident, verified the circumstances, records. A BSCAT incident analysis method was applied and arrived at the following conclusions:

Apparently the activity of handling and stacking of pipes has been considered a routine activity and hence given low priority or no focus.

The leadership for safe execution of the job at successive level was failed. It includes the Contractor's supervision, job supervision, site HSE supervision and project warehouse supervision.

It is the unsafe behaviours which prominently dominated in averting the serious accident.

The systematic barrier based investigation analysis revealed that majority of barriers have been failed to prevent the incident.

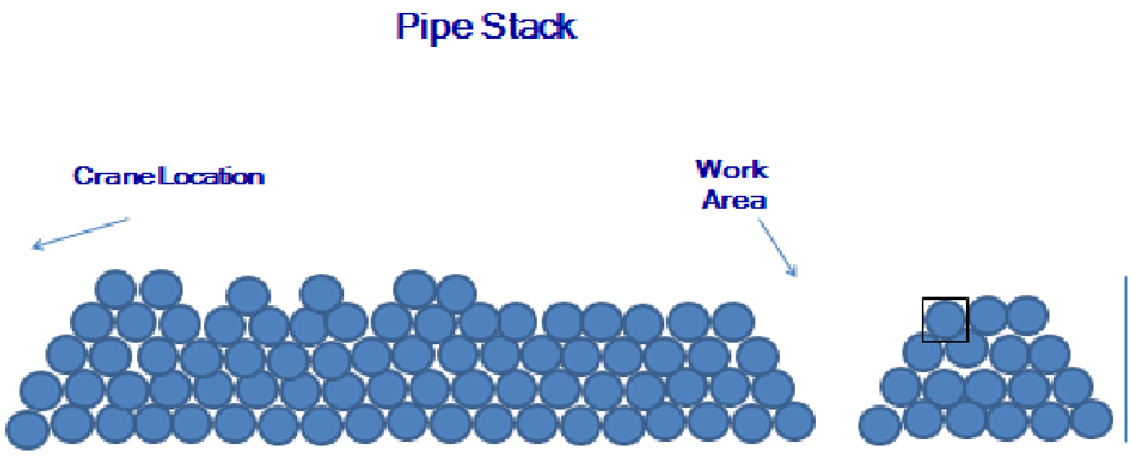


Figure 20: The Schematic of the incident description

Root Causes:

- No planning of work, established safe working methods of stacking and handling of pipes.
- No competent job supervisor was present at work site to supervise the job. The regular supervisor passed on the job to crew and he also left the job site. Therefore, the total activity exposed to a risk of no safety control resulted in serious fracture injury.
- No role clarity on safe job execution and monitoring between contractor and asset owner.

Recommendations

- Activity of stacking and handling pipes shall be recognized as high risk area and implement use of wooden wedges from ground level and upward in each row.
- Stacking and handling of pipes shall be carried out under competent supervision only.
- Explore the possibility of providing cage structure to secure pipes. It is a best practice to ensure no roll over of pipes.

- Reporting of accidents, handling of injured for immediate medical help to be reviewed and all contractors to be apprised of their responsibilities.

Figure 21: Injured in the hospital

When the Scholar interacted with the injured, Mr. Avtar Singh shared the pain and agony that he was going through. He was the only bread winner for his big family and he cannot go for the same job as he was disabled.

According to him poor work place supervision, no safety controls for critical tasks resulted in accident and serious injury.

A Lost Work Day Case- at an Offshore Installation-

A Mechanic sustained with multiple injuries to his face while carrying out pump maintenance.

A mechanic was performing a trial run on engine driven dewatering pump for Effluent Treatment Plant (ETP) maintenance activity. During the trial run, coupling gave away from the shaft and struck Injured Persons (IP) safety helmet & safety goggles. IP suffered a Lacerated cut Injury to his Front Nasal Bridge and lacerated cut injury below Left Eye lower lid.

Immediate Causes: Usage of substandard temporary equipment, absence of coupling guard, lack of standard practices for temporary equipment management, inadequate periodic inspection / while and / or before using.

Basic Causes:

Personal Factors: Relying to IP on his skills to operate and maintain the incident's pump, lack of supervision. Lack of intervention to eliminate unsafe condition.

Job Factors:

Inadequate maintenance/operational practices for temporary equipment, poor, lack of detailed and effective inspection.

Root Causes:

Lack of Control

- Missing basic and mandatory protection devices
- Inadequate work Standards and Compliance

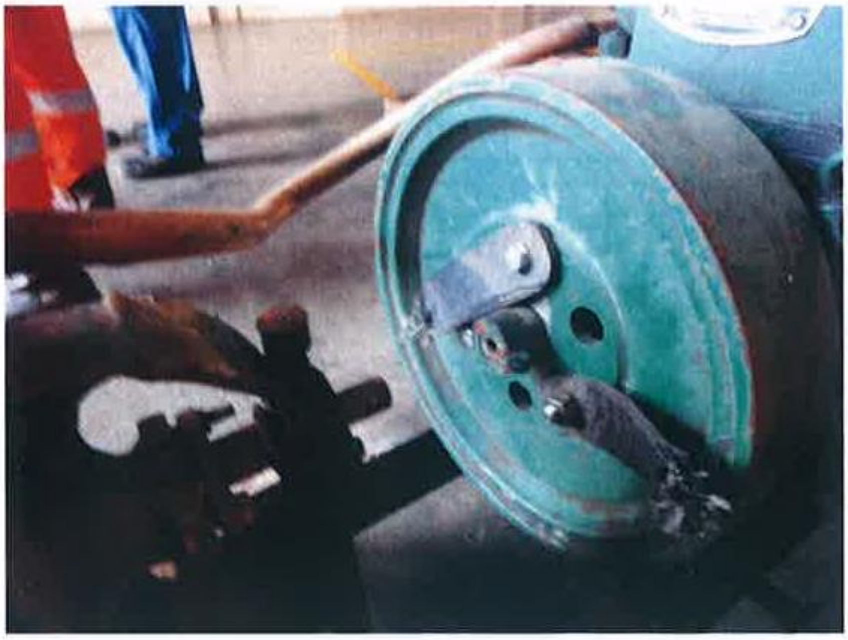


Figure 22: Broken coupling of Pump

Lost Work day Case-Onshore Installation- an Operator fell into a Well Pad Cellar Pit

Two operators headed to their work location to perform their routine work. One operator took a short cut across the cellar pit to reach his work location. He walked on a grating of well pad cellar. Unexpectedly the grating collapsed and the Operator fell into cellar pit through an unprotected opening. The grating cover, for unknown reason, had been removed and was positioned next to the opening. The Operator received multiple injuries (skull fracture, spine fracture and lung contusion) which resulted in lost work day case.

Immediate causes:

The failure to warn of the hazard and to secure the unprotected opening.

Unsafe Acts:

Failure to Secure. The unprotected opening was not barricaded to prevent accidental falling of personnel through the opening.

In attention of the worker: The IP was called back by other workers for participating in daily tool box talk and he was looking back ward while walking forward. This led to the fall into the opening.

Taking shortcut: The IP took a shortcut across the cellar pit to proceed to the worksite. The walk way should be clearly marked or warning posters are to be placed not to walk across the cellar pit over the grating.

Unsafe Condition:

In adequate guards

There was no guard / barricade for the UN protected opening.

Lack of Warning.

The workers were not warned about the presence of an unprotected opening at the work place. There were no warning signs to caution the worker at site.

· Inadequate guards and barriers.

Inadequate Engineering:

The cellar pit grating opening covers are designed inadequately as the grating covers are removable type and can take away from the opening.

Root causes:

· Inadequate engineering of the cellar pit grating openings,
· Lack of hazard identification and
· Improper supervision of the work force at site & lack of attention of the worker.

Lost Work day Case-Onshore Installation- an Engineer fell into a Cable Cellar Pit

Two engineers were on their daily work place inspection at electrical substation area of an onshore well pad area. During the inspection, while walking on false floor / covered with chequered plate, one engineer slip and fell into a cable cellar pit as the cover was not adequately secured. One of chequered plate had shifted and was partially supported. While walking on the floor, IP stepped (right foot) on the partially supported side of the plate and slipped into the opening. The IP struck his left shoulder resulted in fracture and dislocation injuries.

Immediate causes:

Failure to identify hazards, failure to secure, failure to inform/ warn.
Inadequate condition of Floor/ Surface.

Lost Work day Case-Onshore Installation- Dropped Object:

12 1/4" bit and BHA was being pulled out of hole prior to 9 5/8" casing job.
A clamp weighing 26 Kg was tightened by hand on the 8" drilling jar. The Jar was picked up and its bottom connection was unscrewed to lower it on catwalk. While putting protector on pin end of Jar (before it laid down), the clamp fell from the approx.30 feet height from rotary table. It hit on IP head resulting a fracture injury and days lost case.

Unsafe Act:

Failure to Secure (JAR Clamp): Clamp bolts were insufficiently tightened.

Un Safe condition:

Defective Tools (Corroded thread of JAR Clamp): Inspection of Clamp before use was not carried out. Bolts threads had debris, so bolts could not be tightened properly.

Underlining Causes:

- Inadequate verification & inspection of equipment before use.
- Absence of interlock or secondary safety protection.
- Ineffective supervisory control over critical job.
- Inadequate Risk Management.
- Inadequate Training & Competency Assurance for people handling critical operations/ equipment.
- Lack of Communication.

- Inadequate Equipment Specification.
- Poor operation & maintenance checks.

	
Figure 23: Jar Mandrel Clamp	**Figure 24: Clamp Fell on rig floor**

Lost Work day Case-Off-shore Installation- Seaman Injured during Ship to Ship Cargo Transfer

PSV was transferring cargo to MB Krishna. Due to the movement of the PSV caused by the sea conditions the load was swinging and was being controlled by use of taglines, with one tagline on the PSV and two on the MB Krishna. The incident occurred when the tagline on the PSV snagged and broke resulting in the uncontrolled movement of the load across the deck of the MB Krishna. Due to this rapid movement and deck congestion, one of the seamen holding a tagline on the PSV Krishna could not get out of the way and was subsequently struck by the load.

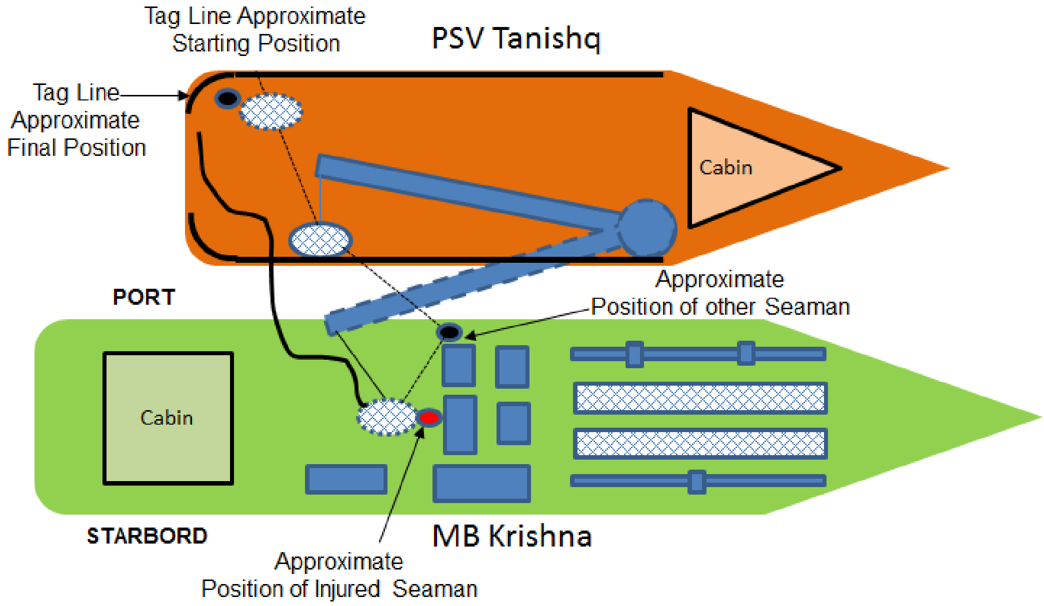


Figure 25: Schematic of LTI Occurrence

Immediate Causes:

Place or Premises

Inadequate access/egress facilities (Insufficient work space for the task in hand. No free space was maintained on the Krishna deck for escape route;

Adverse weather conditions, (weather factor not satisfactorily considered during the transfer operations).

Plant, Equipment

Failure to Secure/Improper loading (use of tag lines to control the movement of load);

Use of inappropriate equipment to transfer cargo (e.g. use of cargo net for gas cylinders).

Process/Procedures

Lack of procedures for task being performed;

People

Poor judgment/decision making (Deteriorating weather conditions was hampering the transfer operation, decision to continue with the operation);
Poor competence (lack of skilled knowledgeable and experienced crew)

Underlying Causes:
Control

Manifest not forwarded to vessel (no details of size and weight of cargo provided to vessels);
Inadequate supervision (particularly on vessels, Tanishq master and deck officer on deck at time but did not adequately supervise the crew involved).

Communication

Ineffective communication covering this type of activity (marine procedure clearly states ship to ship transfer should not be carried out as a routine operation);
Unclear incident reporting protocol, (internal and external).

Design/Engineering

Suitability of both vessels and their equipment for carrying out ship to ship cargo transfers

The need to use tagline round guard rail to try to control horizontal movement of the load.

Competence

Lack of relevant skills (Tanishq seaman holding tag lines having no experience);
Inadequate training (Krishna seaman who was controlling the lifts did not understand the basic communication methods for crane banksman, never had any training;

Risk Management

Lack of risk Management (no risk assessment has been carried out for what is an extremely hazardous activity).

Root Causes:

Inadequate Risk Assessment: High risk nature of ship to ship cargo transfer does not appear to have been considered.

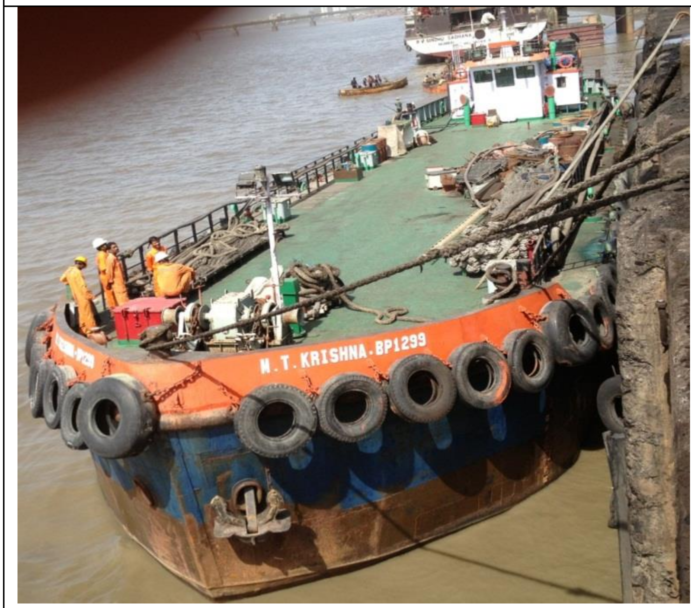
Inadequate Training & Suitability: Gaps in training of some members of ships crews. Particularly in the areas of rigging and lifting operations.

Inadequate Supervision: Applicable to both vessels where there was less than adequate supervision of those involved in the activities.

Tagline pinch point seaman holding the tagline at the point where the line snagged and broke

Figure 26: Accident Location Schematic

PSV

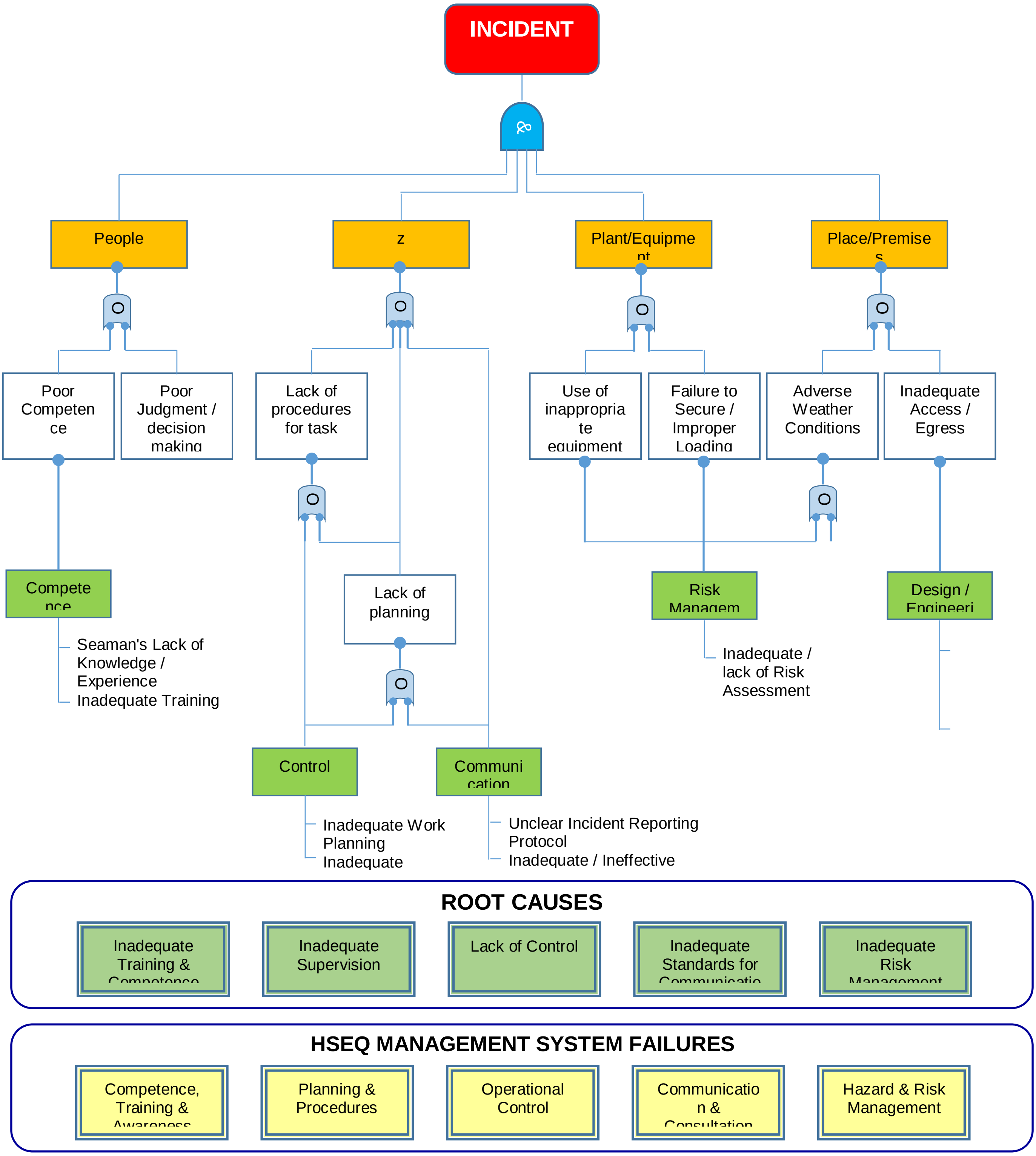


MB

Figure 27: PSV and MB

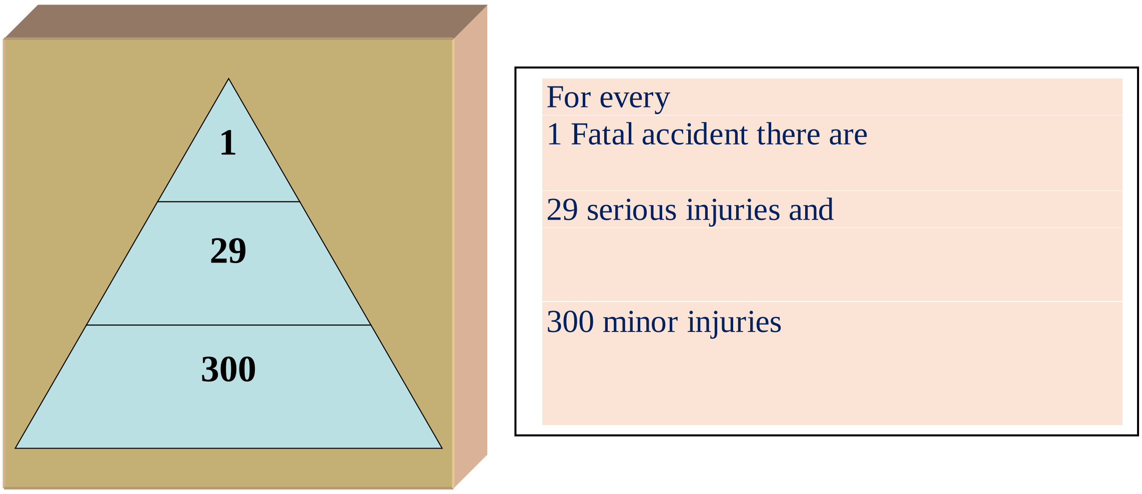
Fault Tree Analysis technique was applied for analyzing the above accident.

Figure 28: Fault Tree Analysis



3.2.3 Oil & Gas Industry Accident pattern Vs Heinrich theory of accidents

Figure 29: Heinrich theory of accidents



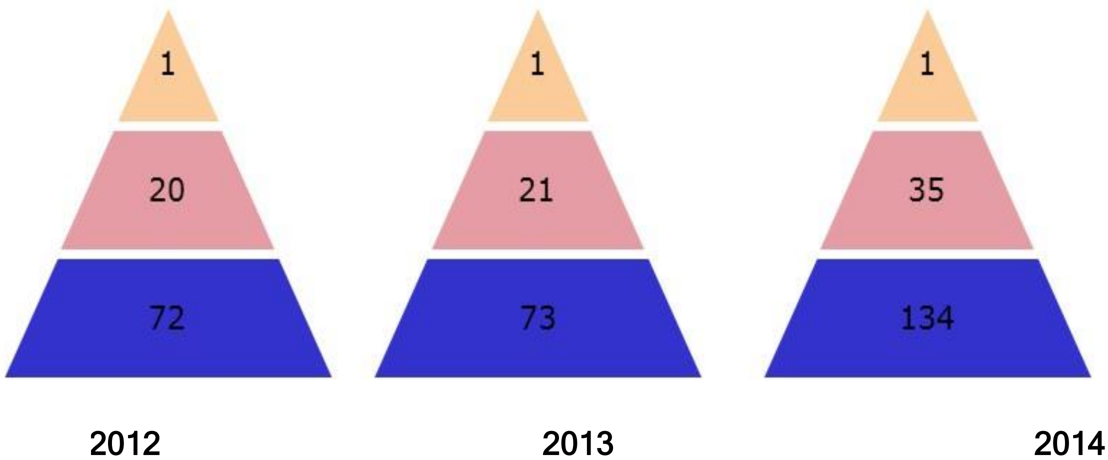


Figure 30: Oil & Gas Accidents Pattern

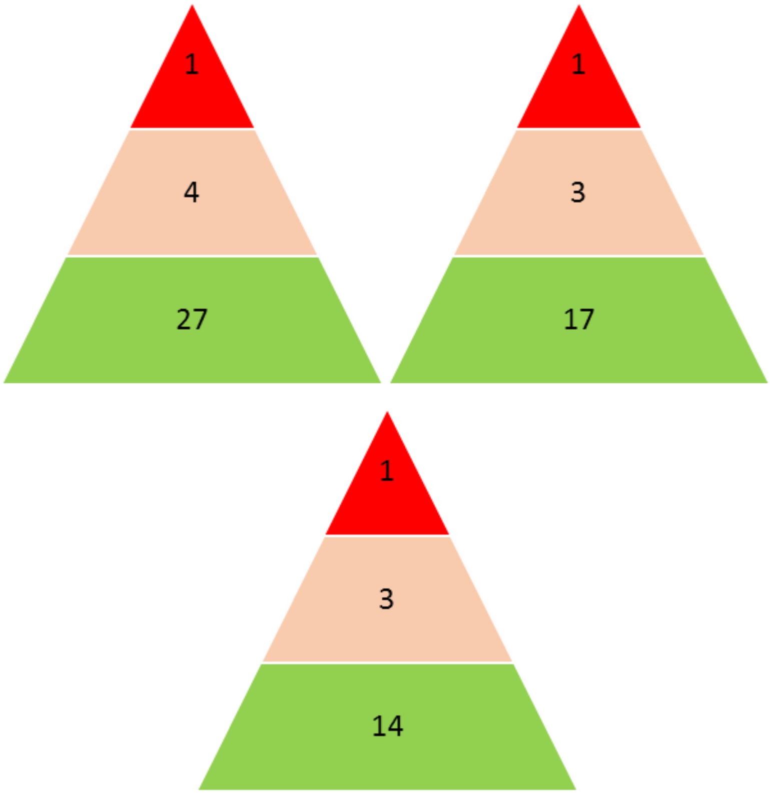
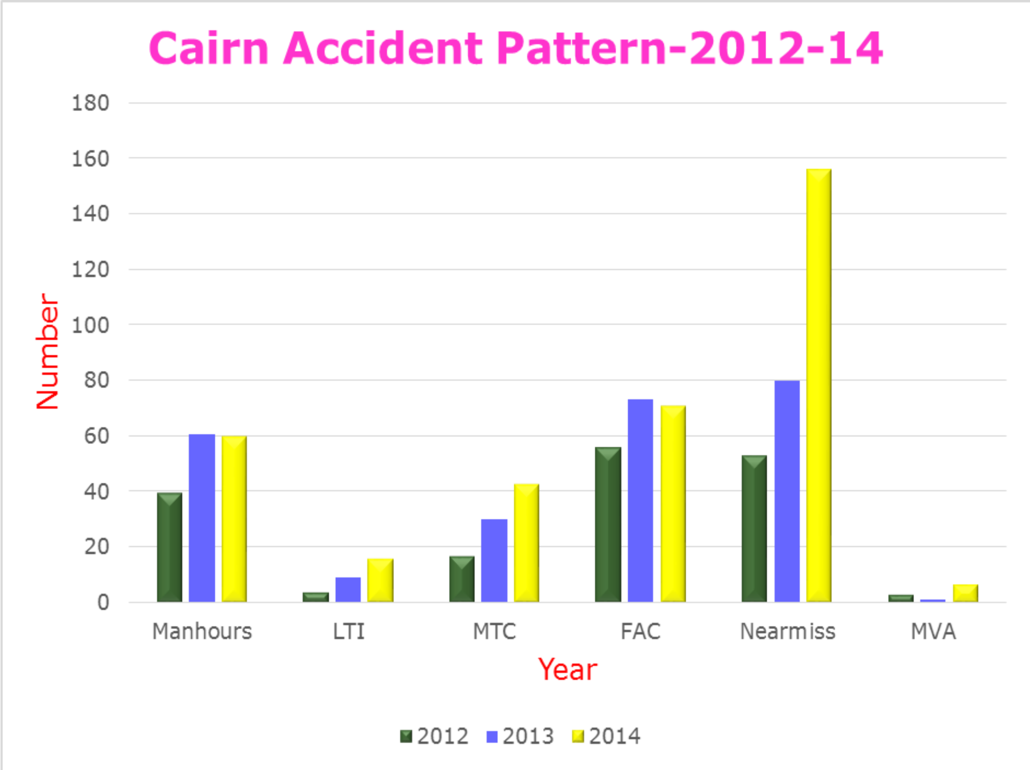
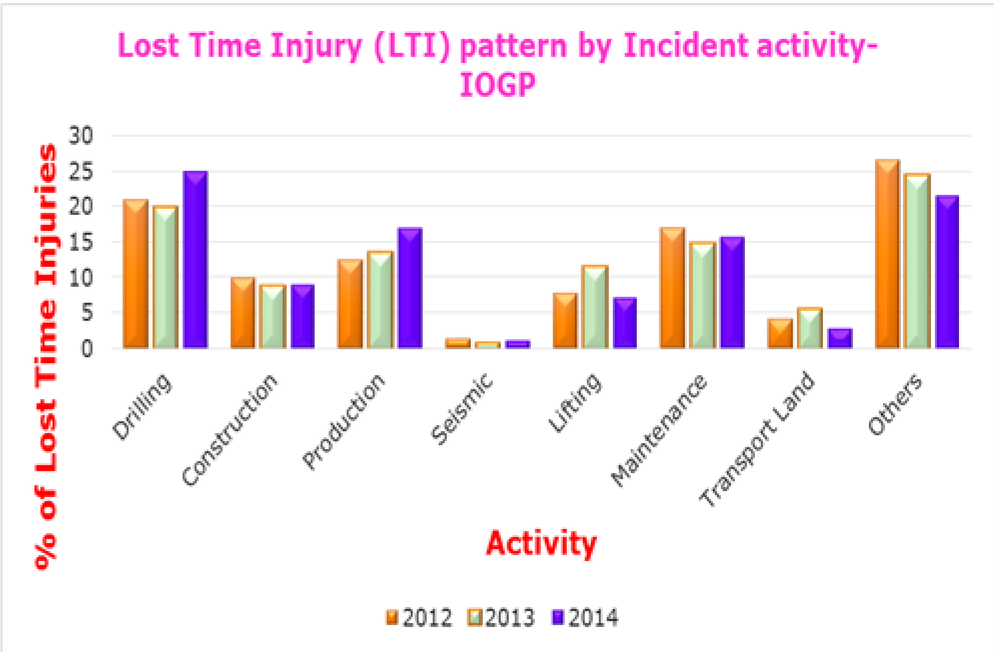


Figure 31: Cairn Accidents Patterns

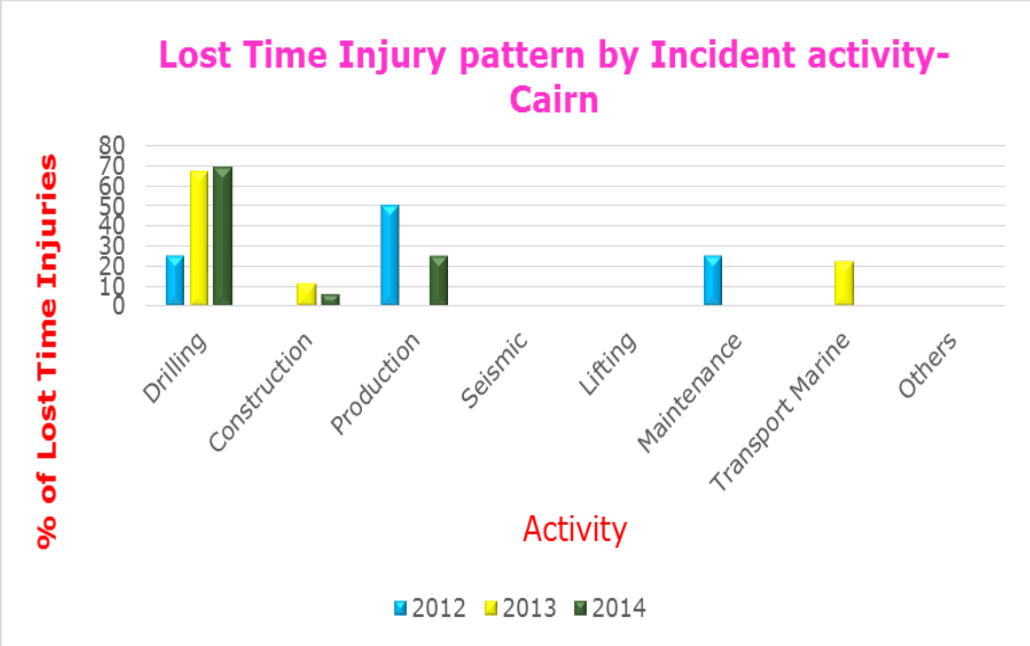
When compared with accident occurring in Oil & Gas industry, the sequence ratio introduced by Heinrich is not consistently accurate.



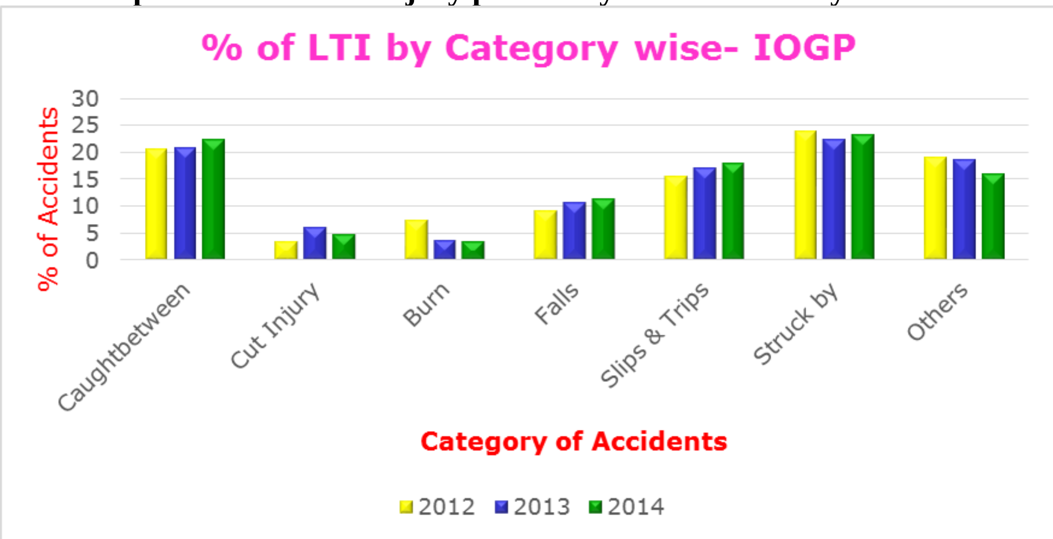
Graph 8: Cairn Accident Patterns-2012-14



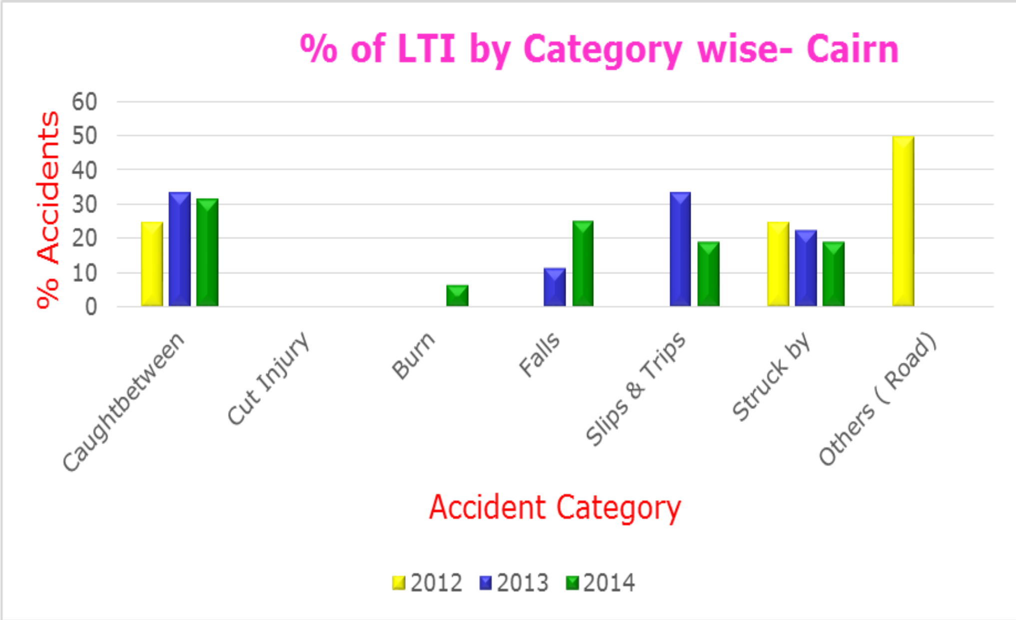
Graph 9: Lost Time Injury Pattern by Incident Activity-IOGP



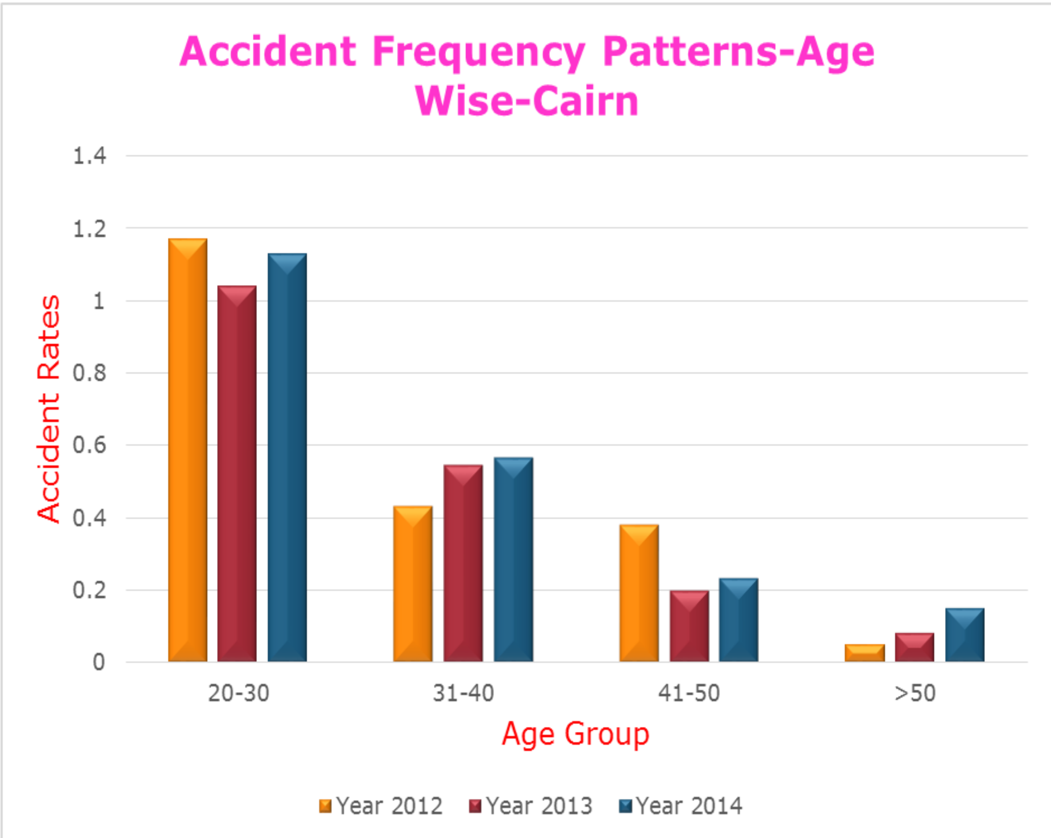
Graph 10: Lost Time Injury pattern by Incident activity-Cairn



Graph 11: Percentage of LTI by Category IOGP



Graph 12: Percentage of LTI by Category Wise-Cairn



Graph 13: Accident Frequency Patterns-Age Wise-Cairn

3.2.4 RESULT

- The patterns suggested by Heinrich is not accurately justifying the patterns of accidents that are occurring in Oil & Gas industry. Therefore, the interpretation of Heinrich theory by the Oil & Gas Company may mislead in designing their work place safety programs.

- A risk of exposure to work place injuries to personnel between age group of 20-30 years in Cairn India found to be more.

- Caught between, slip/trip and fall are similar in Carin and Others Oil & Gas companies.

- More serious injuries are resulting from Drilling activity in Cairn India compared to other Oil & Gas companies.

3.3 STUDY THE INHERENT RISKS FACTORS INCLUDING HUMAN ATTITUDES THAT ARE CONTRIBUTING FOR ACCIDENTS IN OIL AND GAS EXPLORATION AND PRODUCTION INDUSTRY.

3.3.1 Behavioural Based Safety (BBS)

The "application of science of behavior change to real world problems" or "A process that creates a safety partnership between management and employees that continually focuses people's attentions and actions on theirs, and others, daily safety behavior in prevention of accidents."

BBS "focuses on what people do, analyzes why they do it, and then applies a research-supported intervention strategy to improve what people do".

Failure to recognize the hazards at work place is the more emphasized cause in accident occurring. Many Oil and Gas Organization have designed and developed fit for purpose safety management systems to prevent accidents. It includes safety systems like Permit to Work (PTW), management of change, Safety auditing/Inspections, Safety Training and Competency, Safety risk assessment and controls and Contractor Safety management. Based on lessons learnt the Organisations have realized to incorporate BBS as an effective tool in Safety management in prevention of accidents. BBS system address the at-risk behaviors of people and how effectively correct the same and bring sustainable change in safety practices at work place.

These classified “At Risk Behaviours” are the significant contributors in accident causation or great contributors. In several accident occurrence models emphasis given on near misses. The behavioural observations and corrections are further bottom down of the accident pyramid. Several years the industries focused on minor injuries to major injuries prevention rather focusing on changing people behaviour at work place. The concept introduced by DuPont and after several years of practices the subject became a vital tool for Oil & Gas industry in prevention of work place injuries and thus improving sustainable safety culture.

3.3.1 Cairn Observation Program (COP) - a Case Study

Cairn Observation Program (COP) is designed based on behavioural safety concept. The scholar was involved in its designing, launching, awareness programs across the Organization and performance monitoring.

Figure 32: The Scholar Imparting training to field personnel on COP

Figure 26: The Scholar conducting table top COP exercise

The steps involved in the process are the Observer upon getting training, visits the work site with specific objective of preventing “at risk behaviours”. After observing a task, he will intervene with the observee and present the observed safe behaviours. He also shares the “at risk behaviours” or unsafe acts of the observee and explore the options for mitigating the risks. If the corrective action requires the other team member’s intervention, the same will be recorded in the COP card. The observer will thank the observee and close the tour with COP card report.

The program was designed with following five Objectives:

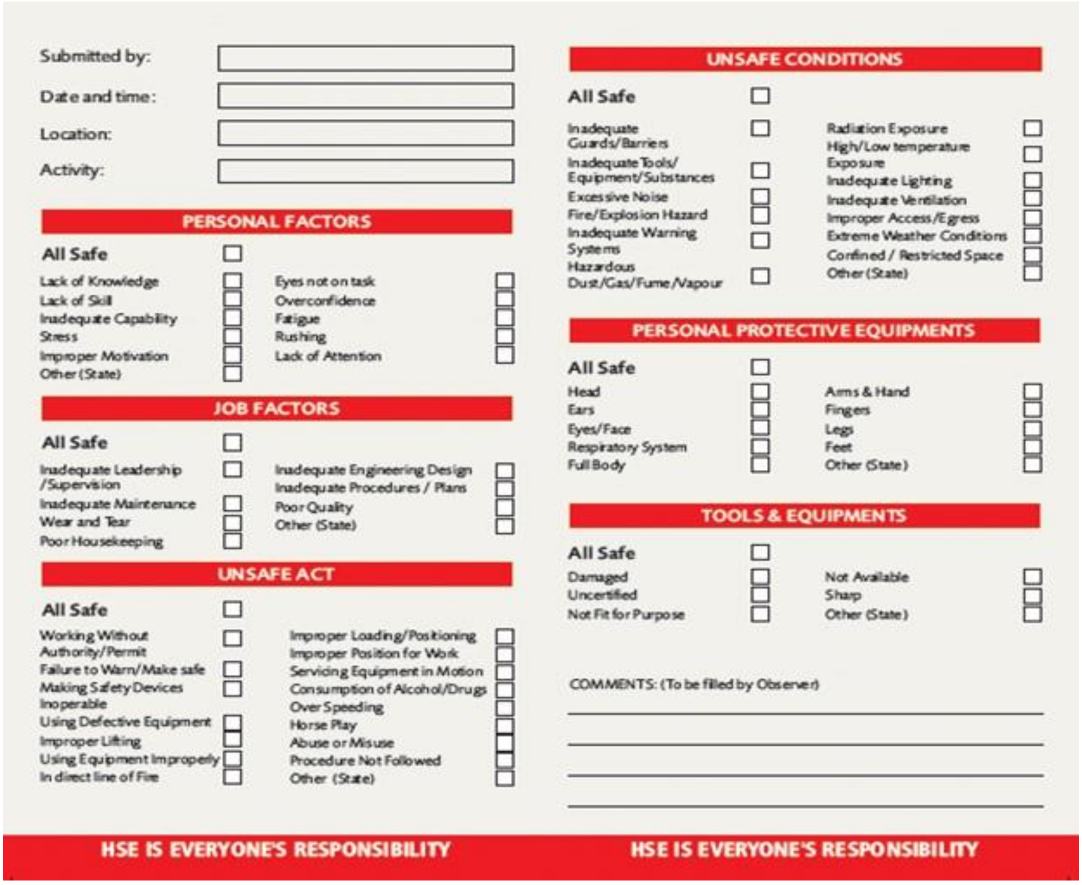
- Personal Factors
- Job Factors
- Unsafe Acts
- Unsafe Conditions
- Personal Protective Equipment
- Tools & Equipment

The above components are further subdivided to capture the micro
Level ‘at risk behaviours’.

It is focused on how People, Plant, Process and Performance managed at work site in prevention of accidents.

The scholar has trained more than 1000 personnel in identifying ‘at risk behaviours’, unsafe acts, interventions for mitigating the safety risk and promoting safety is everybody’s business.

The COP Card used for Behavioural observations:



Submitted by:
Date and time:
Location:
Activity:

PERSONAL FACTORS

All Safe ☐

Lack of Knowledge ☐
Lack of Skill ☐
Inadequate Capability ☐
Stress ☐
Improper Motivation ☐
Other (State) ☐
Eyes not on task ☐
Overconfidence ☐
Fatigue ☐
Rushing ☐
Lack of Attention ☐

JOB FACTORS

All Safe ☐

Inadequate Leadership /Supervision ☐
Inadequate Maintenance ☐
Wear and Tear ☐
Poor Housekeeping ☐
Inadequate Engineering Design ☐
Inadequate Procedures / Plans ☐
Poor Quality ☐
Other (State) ☐

UNSAFE ACT

All Safe ☐

Working Without Authority/Permit ☐
Failure to Warn/Make safe ☐
Making Safety Devices Inoperable ☐
Using Defective Equipment ☐
Improper Lifting ☐
Using Equipment Improperly ☐
In direct line of Fire ☐
Improper Loading/Positioning ☐
Improper Position for Work ☐
Servicing Equipment in Motion ☐
Consumption of Alcohol/Drugs ☐
Over Speeding ☐
Horse Play ☐
Abuse or Misuse ☐
Procedure Not Followed ☐
Other (State) ☐

UNSAFE CONDITIONS

All Safe ☐

Inadequate Guards/Barriers ☐
Inadequate Tools/ Equipment/Substances ☐
Excessive Noise ☐
Fire/Explosion Hazard ☐
Inadequate Warning Systems ☐
Hazardous Dust/Gas/Fume/Vapour ☐
Radiation Exposure ☐
High/Low temperature Exposure ☐
Inadequate Lighting ☐
Inadequate Ventilation ☐
Improper Access/Egress ☐
Extreme Weather Conditions ☐
Confined / Restricted Space ☐
Other (State) ☐

PERSONAL PROTECTIVE EQUIPMENTS

All Safe ☐

Head ☐
Ears ☐
Eyes/Face ☐
Respiratory System ☐
Full Body ☐
Arms & Hand ☐
Fingers ☐
Legs ☐
Feet ☐
Other (State) ☐

TOOLS & EQUIPMENTS

All Safe ☐

Damaged ☐
Uncertified ☐
Not Fit for Purpose ☐
Not Available ☐
Sharp ☐
Other (State) ☐

COMMENTS: (To be filled by Observer)

HSE IS EVERYONE'S RESPONSIBILITY

HSE IS EVERYONE'S RESPONSIBILITY

Figure 33: COP Card

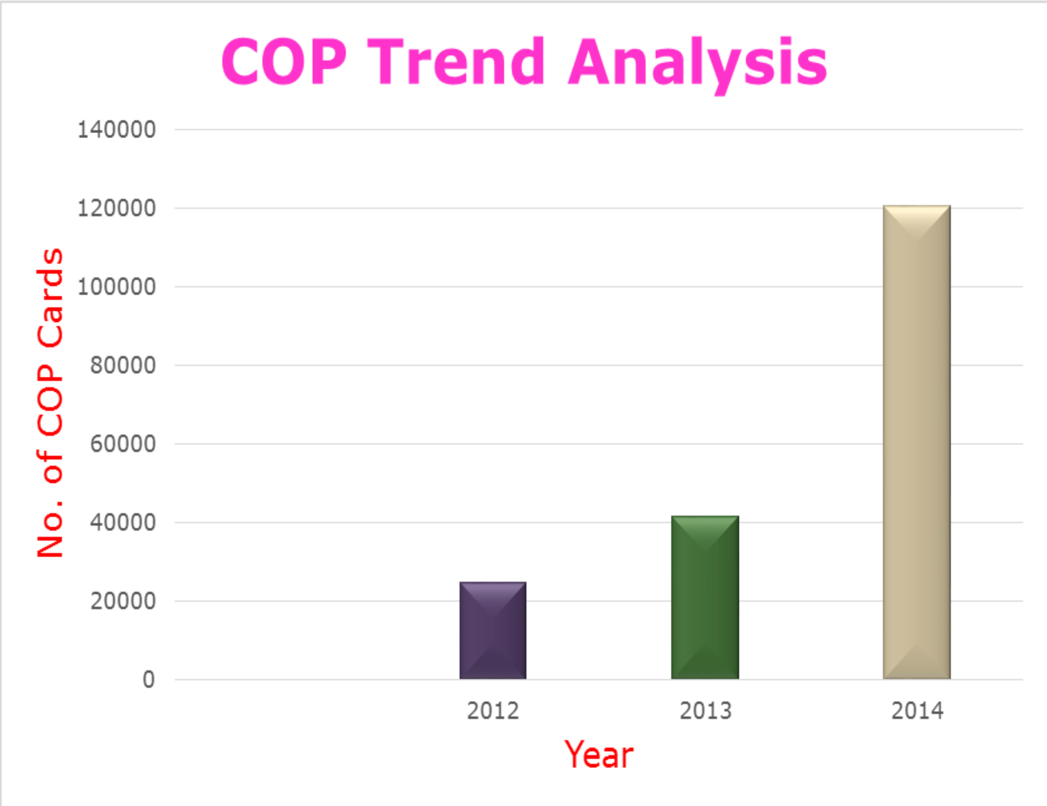
The COP card collection boxes are placed at various work locations to facilitate the employees and contractors to post their observation cards.

Figure 34: COP Box for collecting the observation Cards

3.3.3 Intervention Program Analysis

The COP cards collected at multiple project sites were analysed on weekly, monthly and Quarterly basis. The trend analysis had been carried out to identify the "at-risk behaviours" and its further control.

The Cairn Observation Program over a period of time distributed
As follows:



Graph 14: COP Trend Analysis

A focussed approach of interventions at all levels including the top management, supervisory personnel and contractor personnel has contributed for raise in number of COP cards. Various training programs, street plays and road shows have brought awareness. Recognition of Best COP Cards also contributed for the same.

A) Behavioural intervention observations- (Oil & Gas-Upstream- Drilling and Exploration activities)

A set of behavioural intervention observations pertinent to Drilling and Exploration activities were analysed for the period of 3 years (2011, 2012&2013).

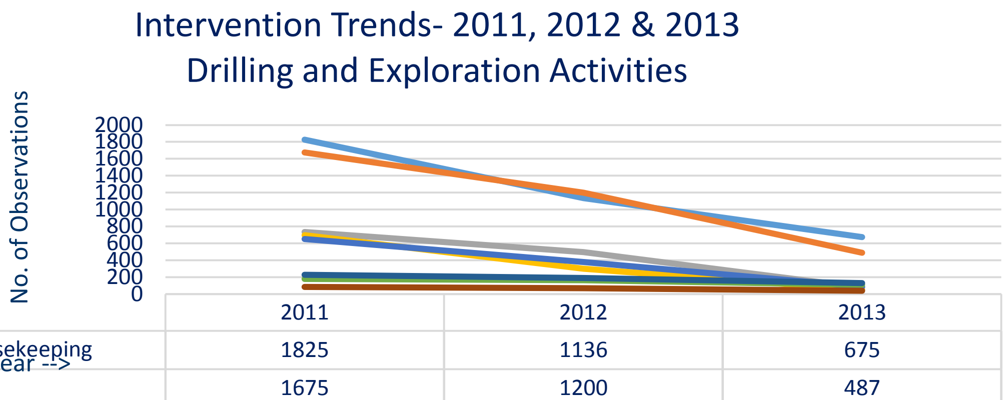
The interventions were focused on Housekeeping, Compliance to Personal Protective Equipment usage, quality of the tools, safe access to the activities performed and compliance to work permit system. Number of interventions were more on these areas and hence incidents are relatively less.

The observations on line of fire (where personnel coming in line with release of energy and exposed for high risk of accidents), failure to identify hazards and poor lifting practices found to be comparatively less and hence more incidents recorded.

Table 7: Behavioural intervention observations- (Oil & Gas-Upstream-Drilling and Exploration activities)

Intervention Element	Nearmis	First Aid Injury	Medical Treatment Injury	Lost time Injury	No. of Observations
Housekeeping	2	1			3636
Personal Protective Equipment	4	1			3362
Tools	5		1		1310
Improper Aggress/Egress	4				1048
Working without authority/ Work Permit	5	0	0	0	1118
Line of Fire	10	6	4	1	192
Failure to identify Hazards	14	9	6	2	452
Improper Lifting	6	7	3		547
	50	24	14	03	11665

Graph 15: Intervention Trends-2011, 2012&2013-Drilling and Exploration Activities



	2011	2012	2013
Housekeeping	1825	1136	675
PPE	1675	1200	487
Tools	735	498	77
Safe Access	698	298	52
Work Permit	652	379	87
Hazard Identification	178	164	110
Improper lifting	229	189	129
Line of Fire	85	69	38

B) Behavioural intervention observations- Oil & Gas- (Process Operations, Plant modification, associated construction activities, drilling and Exploration activities)

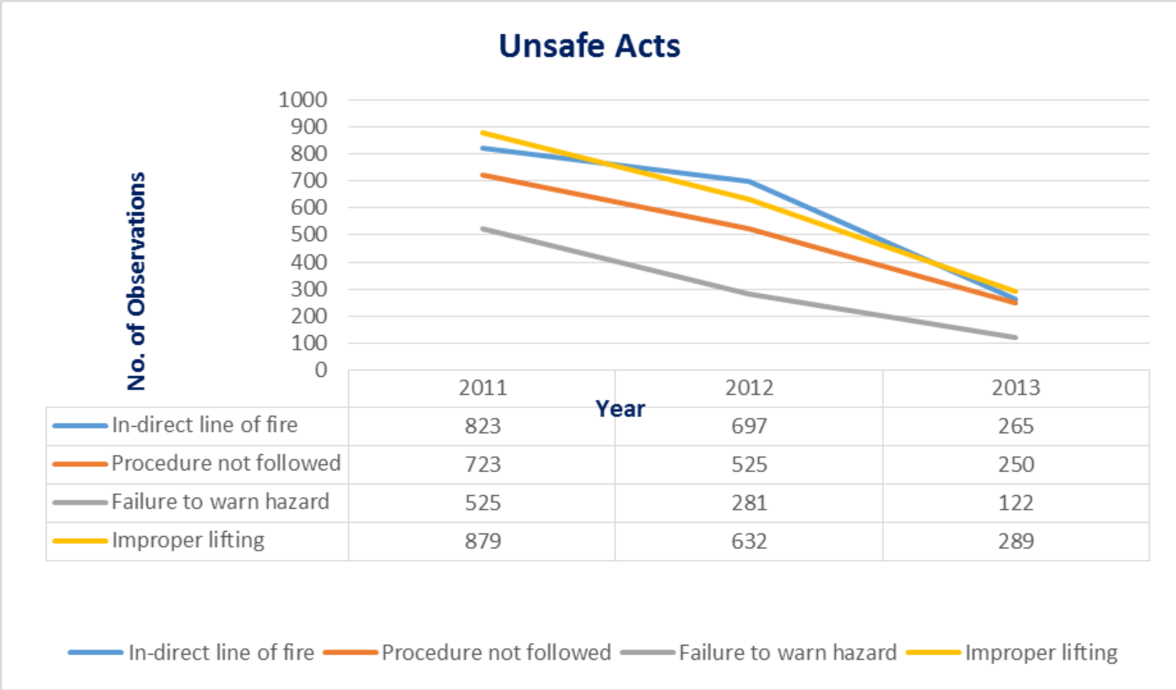
A set of 10000 safety observations cards have been randomly selected for each year (for the period 2011-2013). These interventions are from Plant modification, Process Operations, associated construction, Drilling and Exploration activities. During the year 2011, 65% of these observations were found to be safe work practices. Remaining 35% observations were having unsafe behaviors.

After introduction of Behavioural intervention programs, during the year 2012 the percentage of safe cards have increased to 74% and the unsafe cards to 26%.

After rigorous implementation of intervention programs and inclusion of contractor supervisory personnel, during the year 2013 the percentage of safe cards have increased to 90% and the unsafe cards to 10%.

As the construction activities are hugely dependent on floating contractor manpower, a variation of 20% population is estimated.

From the above data, 2000 ‘unsafe cards’ have been selected for each year and following are the interpretations.

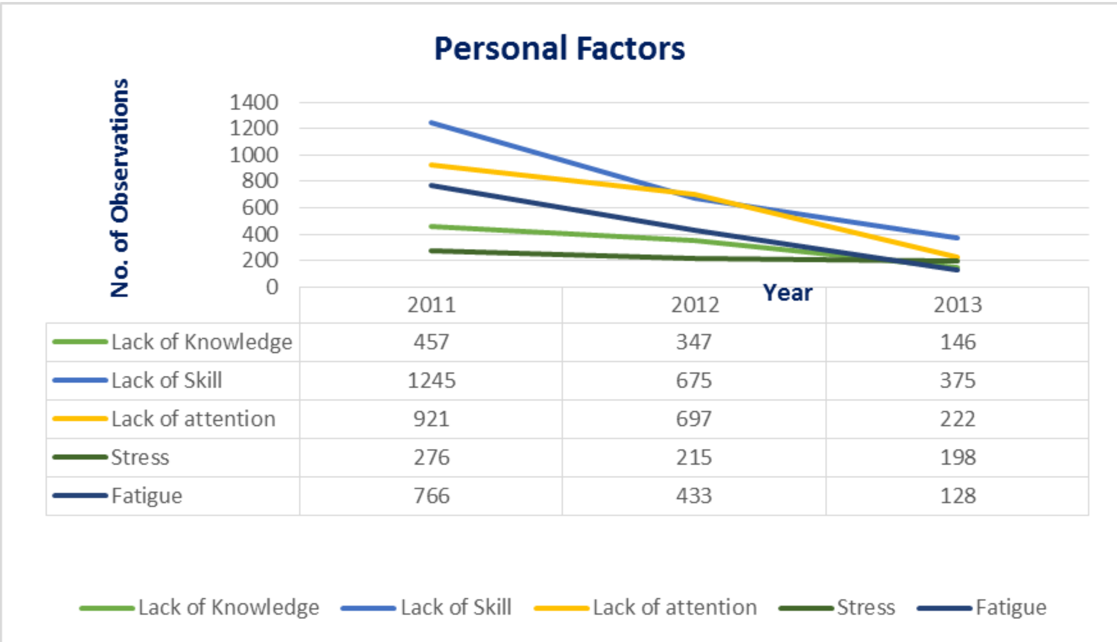


Graph 16: Unsafe Acts

Out of 16 elements of ‘unsafe act’ category, 4 significant elements were analysed and the graph represented in the Graph#16

From interpretation of above trends, the factors including in-direct line of fire, procedure not followed, failure to warn hazard and improper lifting, initially the observation of non-compliance found to be higher and when interventions increased there is a significant reduction of at-risk behaviours. It is interpreted from the IOGP lifesaving rules that controlling of such unsafe behaviours will result in controlling of accidents in oil and gas industry. [Ref: IOGP Life Saving Rules, Report No: 459]

As per IOGP, It is recommended that companies working in the oil & gas industry adopt the OGP Life-Saving Rules. Analysis of 1,484 fatal incidents reported by IOGP member companies over the last twenty years indicates that adoption, conformance and enforcement of these simple Rules may have prevented many of these fatalities. Each company should consider their operations, activities and high potential event history to determine which Rules will be most effective in reducing risk. Companies implementing the rules should, at a minimum, adopt the eight IOGP Core Life-Saving Rules that corresponds to 40% of historical fatal incidents reported to OGP. Supplementary Rules can be selected to address particular risk exposure of the implementing organisation. OGP member companies should actively support their (sub) contractors in implementing the OGP Life-Saving Rules. This standardisation will simplify training and aid compliance and intervention. It is important that the Rules are communicated to all workers, preferably as part of each new worker induction, safety awareness campaign, pre-job discussion, etc.

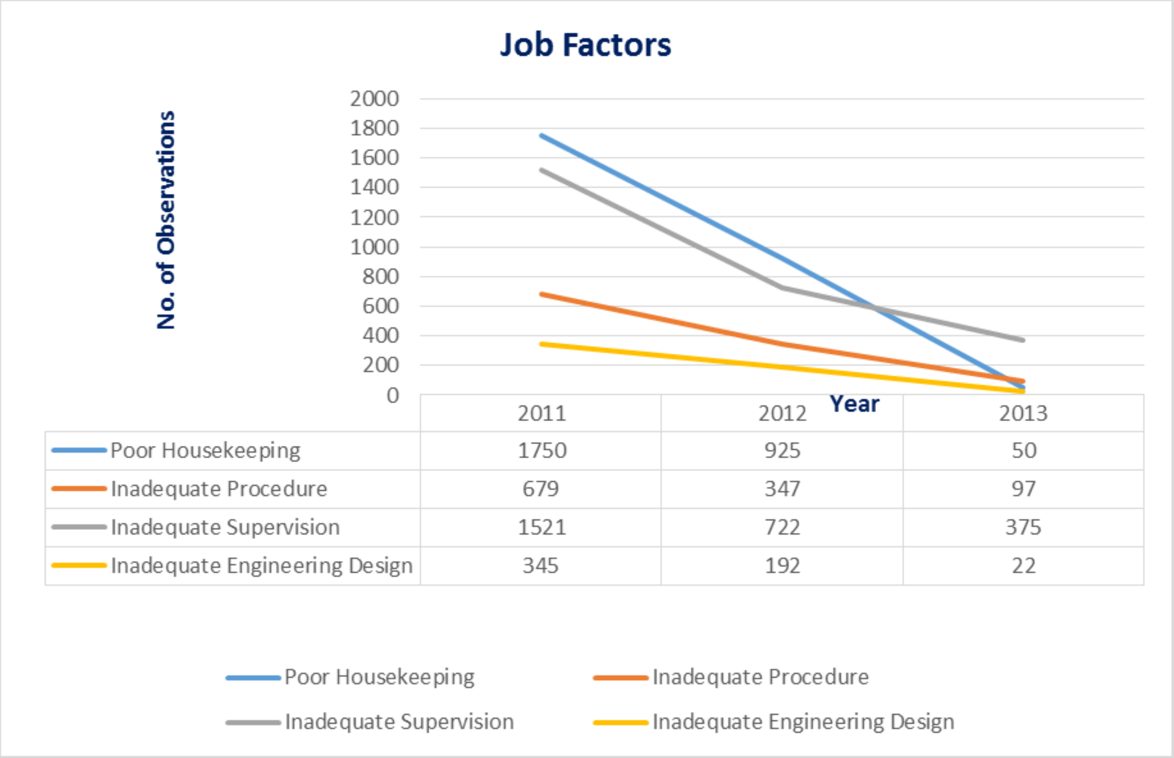


	2011	2012	2013
Lack of Knowledge	457	347	146
Lack of Skill	1245	675	375
Lack of attention	921	697	222
Stress	276	215	198
Fatigue	766	433	128

Graph 17: Personal Factors

Out of 11 elements of 'Personal Factor' category, 5 significant elements were analysed and the graph represented in the Graph#17.

From interpretation of above trends, the factors including Lack of Knowledge, Lack of skill, Lack of attention, Stress and Fatigue initially the observation of non-compliance found to be higher and when interventions increased there is a significant reduction of at-risk behaviours.

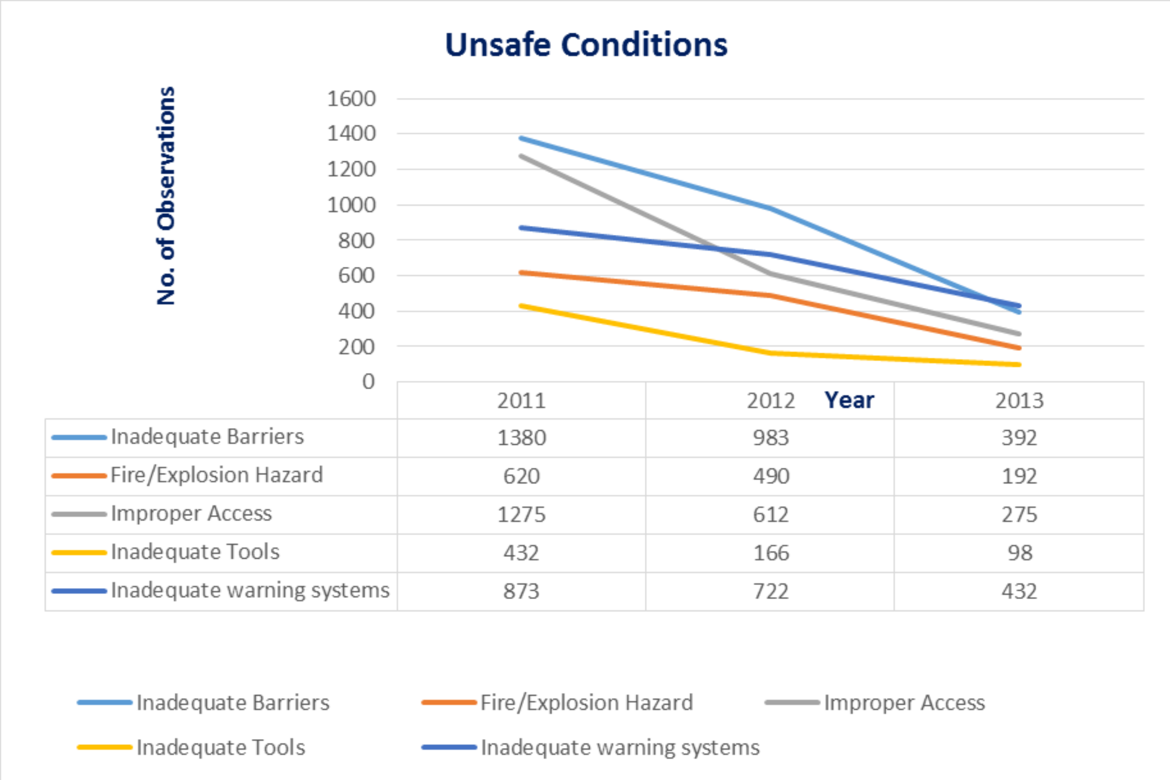


	2011	2012	2013
Poor Housekeeping	1750	925	50
Inadequate Procedure	679	347	97
Inadequate Supervision	1521	722	375
Inadequate Engineering Design	345	192	22

Graph 18: JOB Factors

Out of 8 elements of 'Job Factors' category, 4 significant elements were analysed and the graph represented in the Graph # 18

From interpretation of above trends, the factors including Poor housekeeping, Inadequate Procedure, Inadequate Supervision and Inadequate Engineering Design found to be higher and when interventions increased there is a significant reduction of at-risk behaviours.

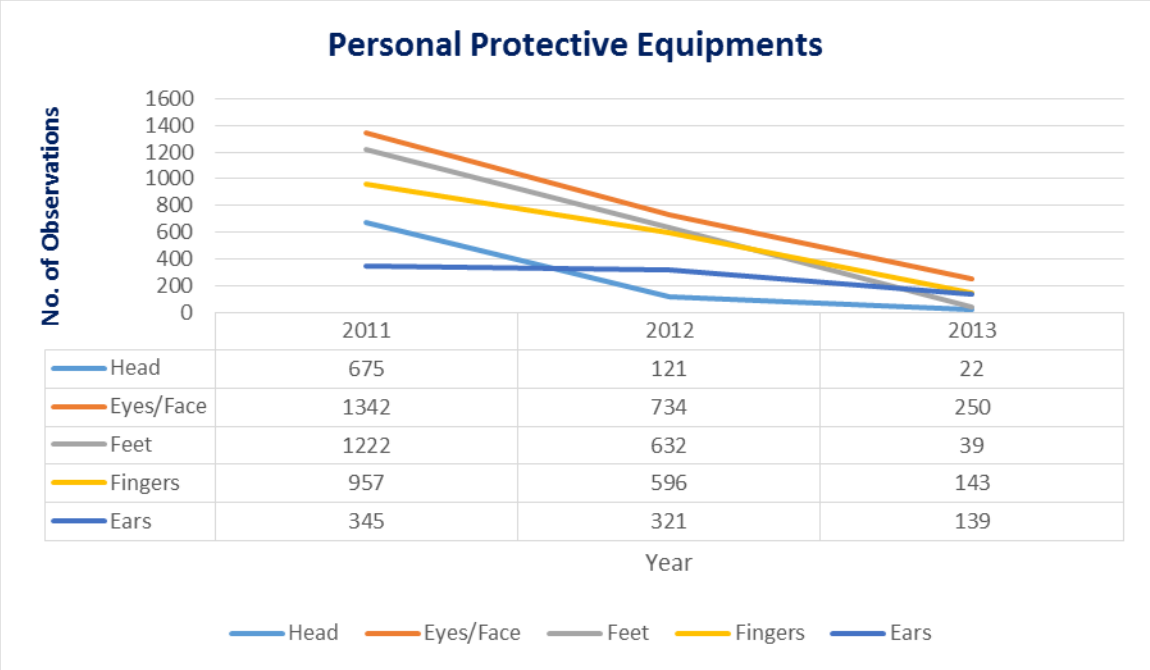


	2011	2012	2013
Inadequate Barriers	1380	983	392
Fire/Explosion Hazard	620	490	192
Improper Access	1275	612	275
Inadequate Tools	432	166	98
Inadequate warning systems	873	722	432

Graph 19: Unsafe Conditions

Out of 14 elements of 'Unsafe Condition' category, 5 significant elements were analysed and the graph represented in the Graph # 19

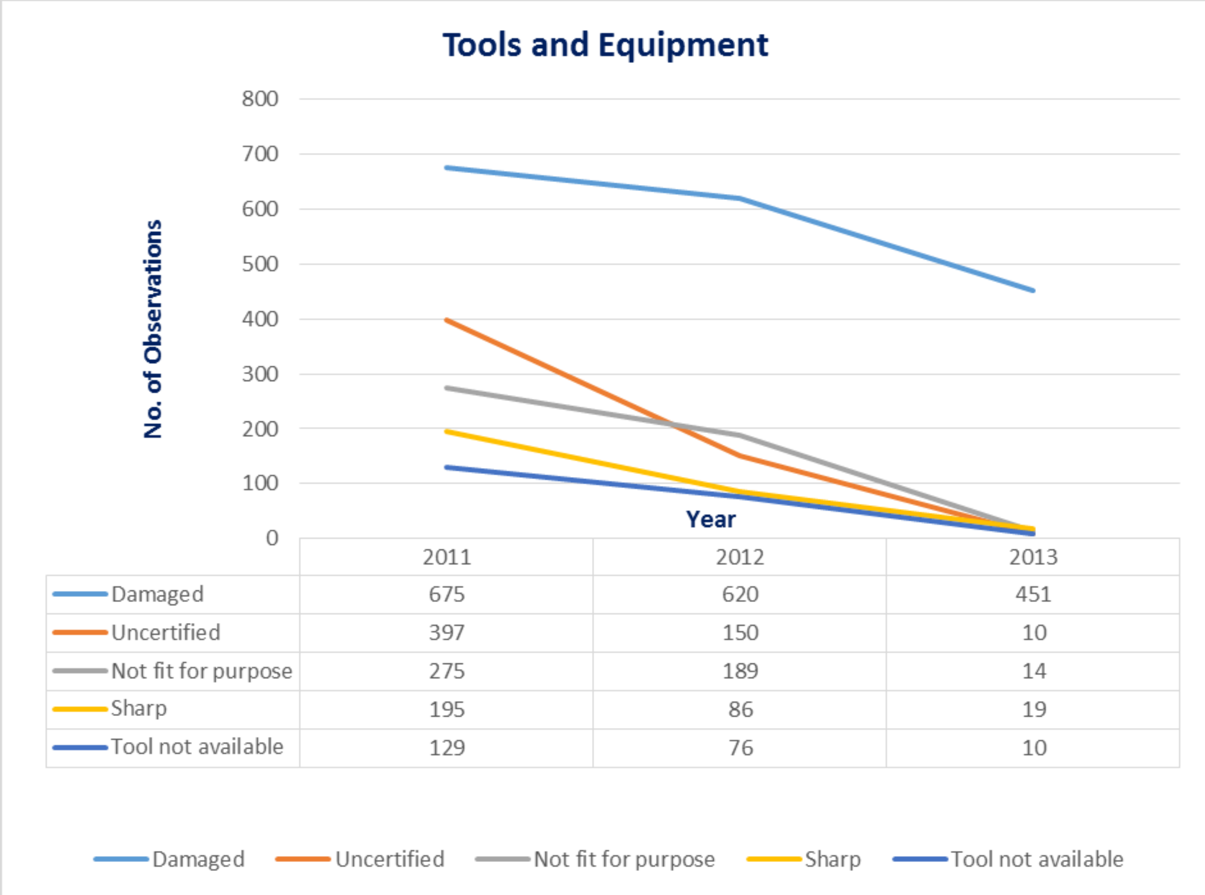
From interpretation of above trends, the factors including Inadequate Barriers, Fire/Explosion Hazard, Improper Access, Inadequate Tools and Inadequate warning system, initially the observation of non-compliance found to be higher and when interventions increased there is a significant reduction of at-risk behaviours.



Graph 20: Personnel Protective Equipment's

Out of 10 elements of 'Personal Protective Equipment' category, 5 significant elements were analysed and the graph represented in the Graph # 20

From interpretation of above trends, the factors including Head (Safety helmet usage), Eye / face protection (goggles, face shields), Feet (safety shoes required for various activities), Fingers (hand gloves) and Ear protection (ear muffs or ear plugs to protect against high noise) the observation of non-compliance found to be higher and when interventions increased there is a significant reduction of at-risk behaviours.



	2011	2012	2013
Damaged	675	620	451
Uncertified	397	150	10
Not fit for purpose	275	189	14
Sharp	195	86	19
Tool not available	129	76	10

Graph 21: Tools and Equipment

Out of 6 elements of ‘Tool and Equipment’ category, 5 significant elements were analysed and the graph represented in the Graph # 21

From interpretation of above trends, the factors including damaged tools, Uncertified tools, not fit for purpose tools, sharp edge tools unsafe way of using and non-availability of tools, initially the observation of non-compliance found to be higher and when interventions increased there is a significant reduction of at-risk behaviours.

C. Behavioural intervention observations- Oil & Gas- (Brown Field activities and Oil Well pad development project activities):

A specific sample was obtained for the COPs captured during the period January-2015 to June-2015. These all observations pertinent to Construction activities associated with Well pads, and associated activities.

The observations focused on unsafe acts, unsafe conditions, and job factors, tools which are most probable and general causes in Construction environment.

639 Behavioural intervention cards have been considered for this analysis. It appears that the activities those commonly being executed on day to day basis and the observers made maximum number of observation on those activities, are having less number of incident or no incident (Marked in Green).

At the same time the common activities those being executed on day to day basis but having less COP observation, are having more number of incident (marked in RED).

It is concluded that the theory of behavioural modulation can be proved right through this data. More monitoring and interference by first line management on a particular activity can help to reduce the Chance of incident greatly in that area.

Table 8: Table of COP Observations- (Brown Field activities and Well pad development project activities)

Intervention Element	Nearmis	First Aid Injury	Medical Treatment Injury	Lost time Injury	No. of Observations
Housekeeping	4	0	0	0	439
Personal Protective Equipment	16	0	0	0	479
Tools	5	0	0	0	198
Improper Aggress/Egress	2	1	0	0	130
Working without authority/ Work Permit	2	1	0	0	128
Line of Fire	4	6	4	1	14
Failure to identify Hazards	4	18	4	1	22
Improper Lifting	3	12	8	0	51
	40	38	16	2	1467

90% of Observations reflecting safe work practices demonstration by the workforce.

These observation programs made an opportunity for all level of personnel to involve in building safety culture.

The remaining 10% Observations are attributed as per contributing factors listed in COP card are Unsafe acts (Line of fire, working without work permit), Unsafe conditions (Improper access/egress, Inadequate tools), Personal factors (Lack of skill, stress), Job factors (poor housekeeping, inadequate supervision) and PPE.

The trends are interpreted as:

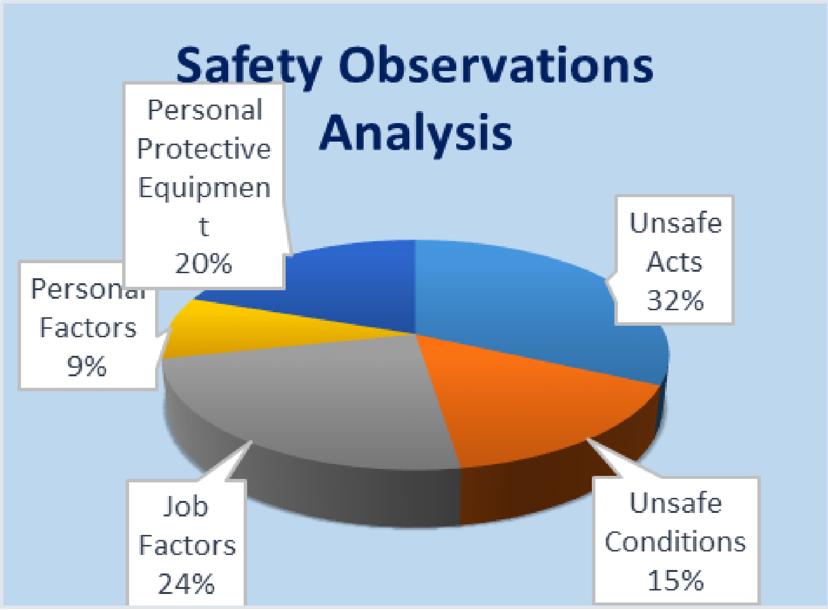


Figure 35: Safety Observation Analysis-Brown Field activities and Well pad development project activities

Unsafe acts (32%) found to be the major contributor followed by Job factors (24%) and noncompliance to personal protective equipment (20%). Unsafe acts including are procedures not followed and failure to make work place safe. The Job factors include inadequate leadership / supervision, poor housekeeping issues. Therefore all these factors may be corrected with employee engagement process, timely interventions and positive feedbacks.

The barrier in the process found to be

- Inadequate visibility of Top Leadership on the ground
- Lack of ownership from Front line Supervisors
- Contractor performance monitoring and control

- Poor competency levels of Contractor supervisors
- Delayed response in closing unsafe conditions/acts

Typical Safety Observations in the study found to be:

- Stopper for the Pipe rack were not in practice. This repeat observation resulted in a lost time injury involving roll over of pipes and a contractor workmen was trapped in between the pipes. It is significant that overlooking the safety observations lead to near-misses and further repetition of same incidents lead to serious accidents.
- Personnel found not using three point contact while ascending or descending the ladders or stair cases. This symptom when ignored resulted in a lost time injury where in a contractor person fell from a ladder lead to lost work day case.
- Poor controls on grating management includes either gratings are missing at platforms or not properly fixed have created a high risk incidents.
- Poor housekeeping includes, slippery floors, tools on floor, access / egress.
- However, a significant improvement on housekeeping at work place was observed through safety observations reports.
- Noncompliance to use of personal protective equipment.

3.3.4 Near miss and Behavioural interventions

Near-misses are defined as the incidents have just occurred with a potential to cause serious injury or damage but did not result in. An event which under slightly different circumstances could have resulted in an injury/damage/loss. Generally such events are unplanned and the consequences are avoided by circumstances.

Examples:

Tripped or slipped while walking down the stairs, but held on to some form of support thus avoiding the risk of injury

While lifting a bundle of cable trays using crane, few trays slipped and fell from a height. The rigging crew who just left the spot have escaped without injury where the trays fell on ground.

Near-misses play a vital role in accident prevention. In the hierarchy of accident occurring pyramid, near-misses take the bottom of the place. However, they are the significant contributors for a serious accident to occur if they are not analysed and prevented recurrence of the same. Near misses are smaller in scale, relatively simpler to analyse and easier to resolve. Thus, capturing near misses not only provides an inexpensive means of learning, but also has some equally beneficial spin-offs.

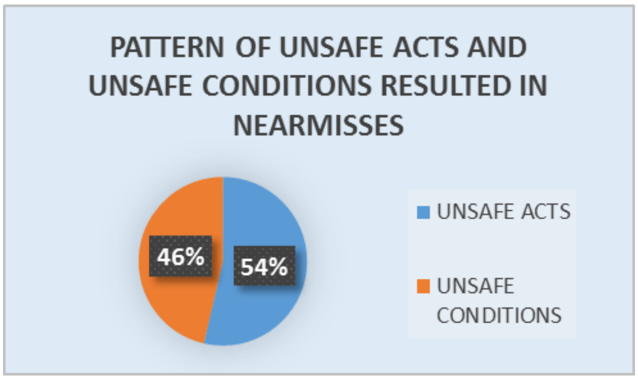
Near misses provides immense opportunity for "employee participation," a basic requirement for any successful HSE Program.

Near-miss system creates an open culture whereby everyone shares and contributes in a responsible manner. Near-Miss reporting has been shown to increase employee relationships and encourage teamwork in creating a safer work environment.

Many Organizations have reporting of near-misses, analysis of near-misses and publish lessons learnt from the same to prevent reoccurrence. However, many research studies indicate that near-miss reports are still not optimally used for learning. One potential barrier is that the definition of a near miss is unclear.

At risk behaviours and unsafe conditions are another set of contributors for accident. However these are fundamentally associated with human behaviours at work place. They are greater in number than the near-misses. Over a period of time, Behavioural changes and self-realization of the personnel at work place, timely interventions, only reduces the incidents. These are the core values of safety culture.

About 250 near-misses occurred during the year 2012-2015 at Cairn India were studied and the pattern is represented as



Graph 22: Pattern of Unsafe Acts and Unsafe Conditions Resulted in near-misses

54% of near-misses have been contributed by unsafe acts and are directly associated with behavioural aspects.

Following are the few examples of near-misses extracted from the sample.

- During routine plant round, an engineer hit against a 1/8" tubing on the platform and got tripped. He balanced himself holding the handrail. The tubing was of moisture analyser and falling in the walkway causing a potential trip hazard.

- While lifting a bundle of cable trays using crane, few trays slipped and fell from a height. The rigging crew who just left the spot escaped without injury where the trays fell on ground.

- The majority of near-misses are due to fall of objects at rig floor, fall of personnel from height, collapse of false ceiling, zero tolerance behaviours, not adhering to safety procedures.

3.3.5 RESULT

- Attitudes are directly related to accidents. Behavioural intervention analysis has supported this in terms of reduction of accidents in particular activity.
- Detailed analysis of six behavioural factors as listed in the COP card has resulted in reducing the accidents when Consistent Behavioural interventions applied.
- Near miss is significant part of accident occurring.
- Recognizing the nearmises, analysing the root causes and preventing the reoccurrence contributes for reduction of accident.

3.4 STUDY THE CURRENT METHODOLOGIES OF ACCIDENT ROOT CAUSE ANALYSIS THAT THE OIL AND GAS INDUSTRY ADOPTED AND SUGGEST IMPROVED METHOD.

3.4.1 Root Cause Analysis

Root cause analysis (RCA) is a technique used to identify the root causes of an incident. It helps in preventing similar recurrences of incidents. An effective RCA can be used to target major opportunity for improvement.

Limitations of Root Cause analysis:

The term root cause captures two critical assumptions. The first assumption is to find the causes having no internal structure. The other assumption is that sub causes are independent and manageable. Both assumptions are invalid in human systems.

3.4.2 5 Whys

It is an effective root cause analysis technique for analyzing the accidents. It is originated at Toyota and adopted by many other Organization. It repeatedly asks the question “Why?” at least five times to successively eliminating the possible symptoms that supports in identifying the root cause of a problem.

Limitations of 5 Why Analysis:

This technique is highly depend on the competency of the person analyzing the problem.

This process assumes that there is only one contributing cause for an incident. However, thee would be many sub causes contributing for an incident.

Therefore the 5 Whys analysis may not disclose sufficient causes that explain an incident.

The technique is fully depend on the skill with which the method is applied. If even one Why has an inadequate answer the entire analysis may not give good result.

Different results emerges when different people apply the 5 Whys for the same incident. Therefore it is fully dependent on the skill and exposure of the person analyzing the incident.

It is having limitation to distinguish between causal factors and root causes.

3.4.3 Bow-tie analysis

It is a visual tool gives the effectiveness of barriers preventing a top event resulting from a hazard. It is a Bow Tie methodology is a simple and pragmatic approach to identify the causes for an accident.

It is originated as a technique for developing a “Safety Case” in the Oil & gas Industry, post the Piper Alpha Incident in 1988.

By linking “Hazards’ & Consequences” to an ‘Event’ it is possible to develop the relationship to include the causes, or ‘Threats’, and the ‘Prevention’ & ‘Recovery Measures’

Further understanding can be gained by examining the means by which these defences can fail, and identifying the key components which demonstrate the integrity of these controls.

Bow tie representation:

The process of Bow-tie is represented as follows.

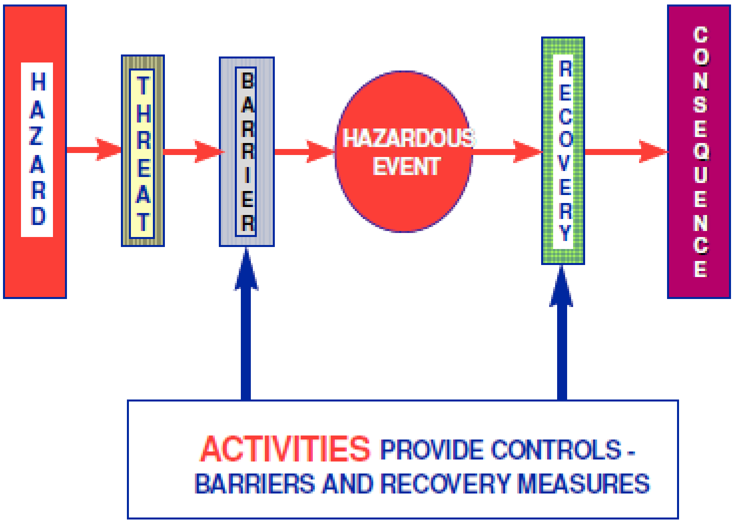


Figure 28: Bow-tie Schematic

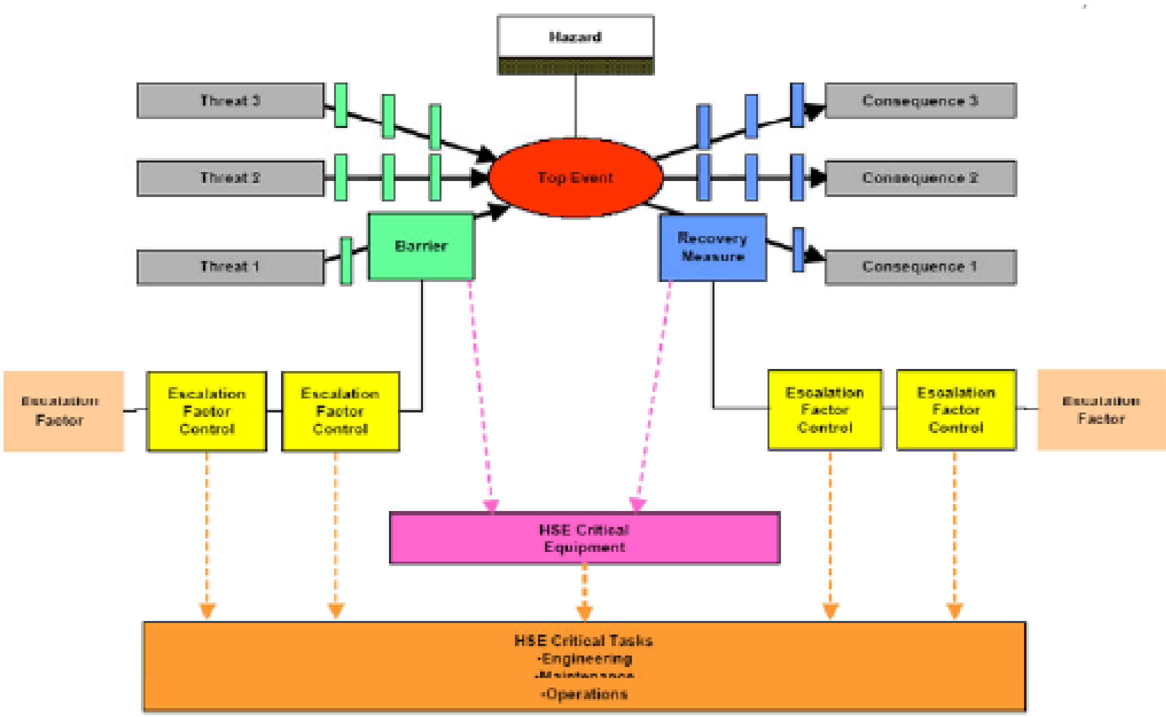


Figure 29: Bow-Tie with Barrier and control Mechanism

3.4.4 Fish-bone analysis

Fish-bone diagram is a cause and effect diagram which represents basic, immediate and root causes. It identifies possible causes of a problem. It is a visual diagram to represent the cause and effect. It is a more structured approach.

The head or mouth of the fish represents the problem or effect. The small bones represents contributing causes. It is widely used in root cause analysis in conjunction with 5 why techniques. It analysis result depends on the visualisation of the analysist.

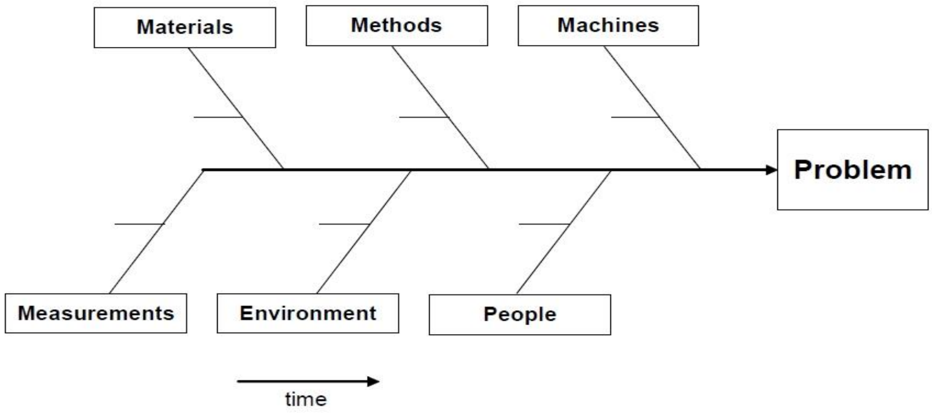


Figure 36: Fish Bone Model

<u>Limitation of Fish-bone analysis</u>

Depends on the knowledge and skill of the analyst and missing underlining causes.

3.4.5 Swiss cheese Model

It is a model used in risk analysis and risk management.

It illustrates that the workplace injury results from an accident when a hazard passes through defined barriers. The barriers resembles to Swiss Cheese slices stacked side by side. Therefore analyzing the accidents using Swiss Cheese model provides an opportunity to identify the root causes. Also one can verify the strengths and weakness of defined safety controls in prevention of accidents.

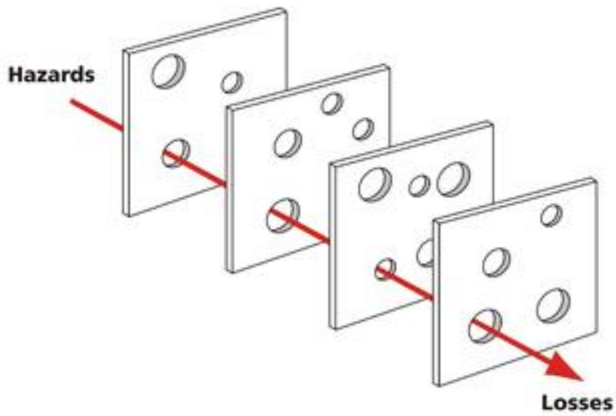


Figure 37: Swiss cheese Model

Analysis of an accident using Swiss Cheese Model - A Case Study

A contractor person was ascending the ladder for tightening the wire mesh provided at the rear of exhaust fan in 6.6 KV electric substation. While ascending the ladder, ladder itself slipped and (Injured Person) IP fell on ground from the height of around 3 meters. IP sustained displaced spiral fracture of proximal shaft of femur on right leg thigh.

The sequence of events were prepared and causal factors were analysed using BSCAT technique.

The incident was caused due to usage of Non self-supporting ladder (Not fit for this type of work) under no supervision for working at heights without obtaining Job permit & failure to identify hazard and conduct task risk assessment.

Root cause Identified includes Hazard and Risk management in terms of Effectiveness of risk identification and control, Operational control for supervision,

Training and Competence of the staff for working at height using appropriate Ladder.

Figure 38: Close view of incident site

Figure 39: Accident Scenario-Fall from Ladder case.

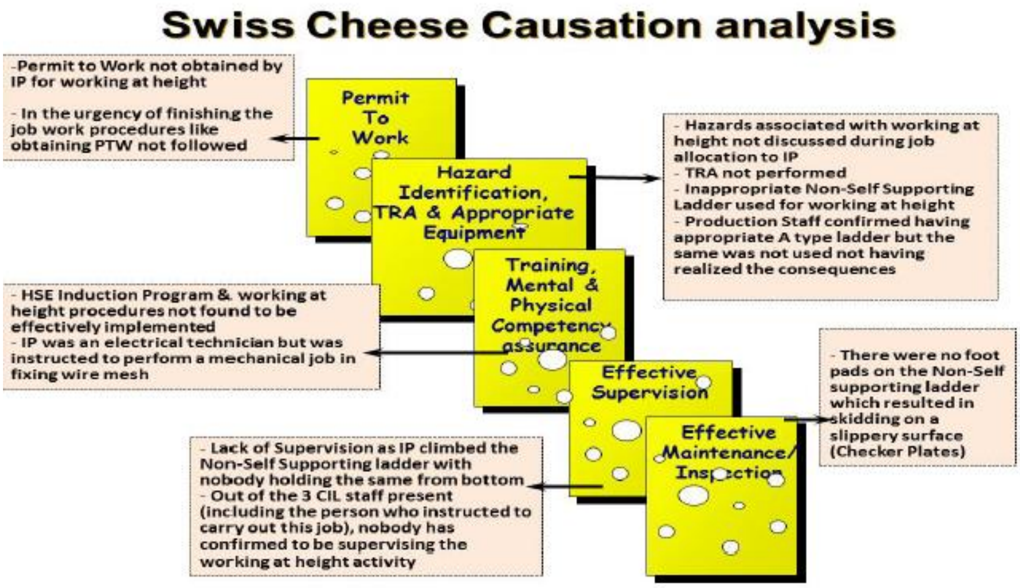


Figure 40: Swiss cheese Model

<u>Limitation of Swiss cheese Model</u>

It is having limitation of integration with other mathematical models.

3.4.6 Barrier based Systematic Cause Analysis Technique (BSCAT)

It refers to a method that links modern risk–based safety management approaches to systematic root cause incident investigation.

The "B" refers to barrier–based as each barrier identified in bowtie risk assessments is tested for why it failed. SCAT™ is Systematic Cause Analysis Technique.

The model is a sequence of dominos establishing the hierarchy of accident progression from the immediate cause back to fundamental root causes and system failures.

BSCAT is an incident analysis tool. It supports in depth verification of barriers for incident analysis. This technique uses pre-existing Bowties or can be used on its own. It is the first method to link risk assessments with incident analysis. The schematic is represented in Figure #41.

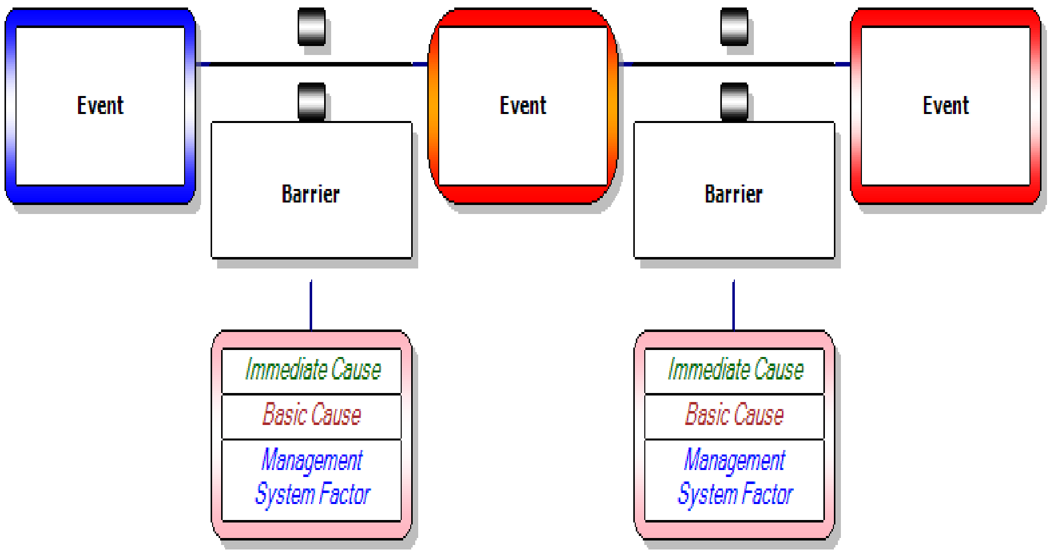


Figure 41: BSCAT Model

Analysis of an accident using BSCAT - A Case Study

The details of case study has been discussed in Section 3.4.5.

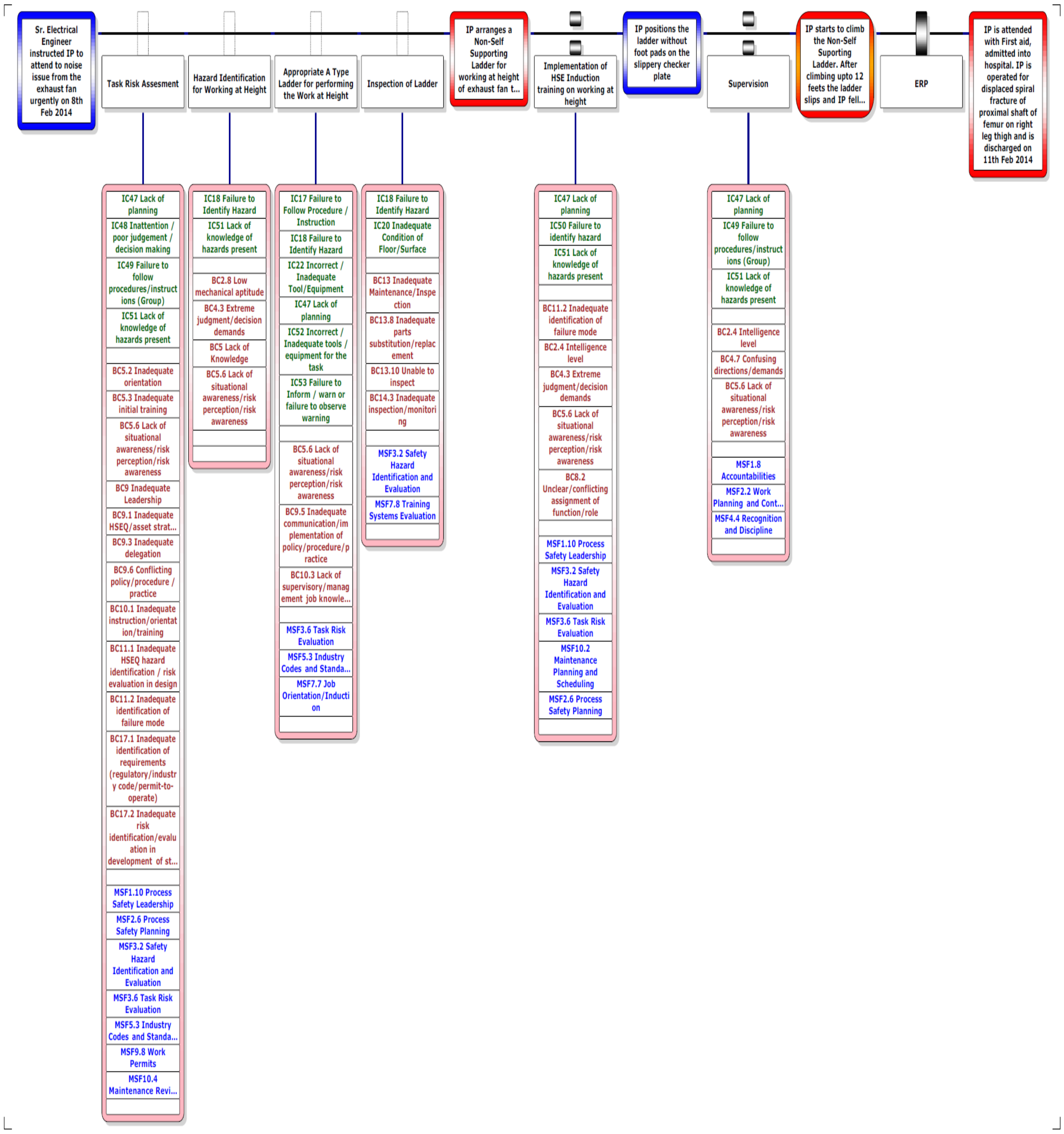


Figure 42: BSCAT Analysis of an accident

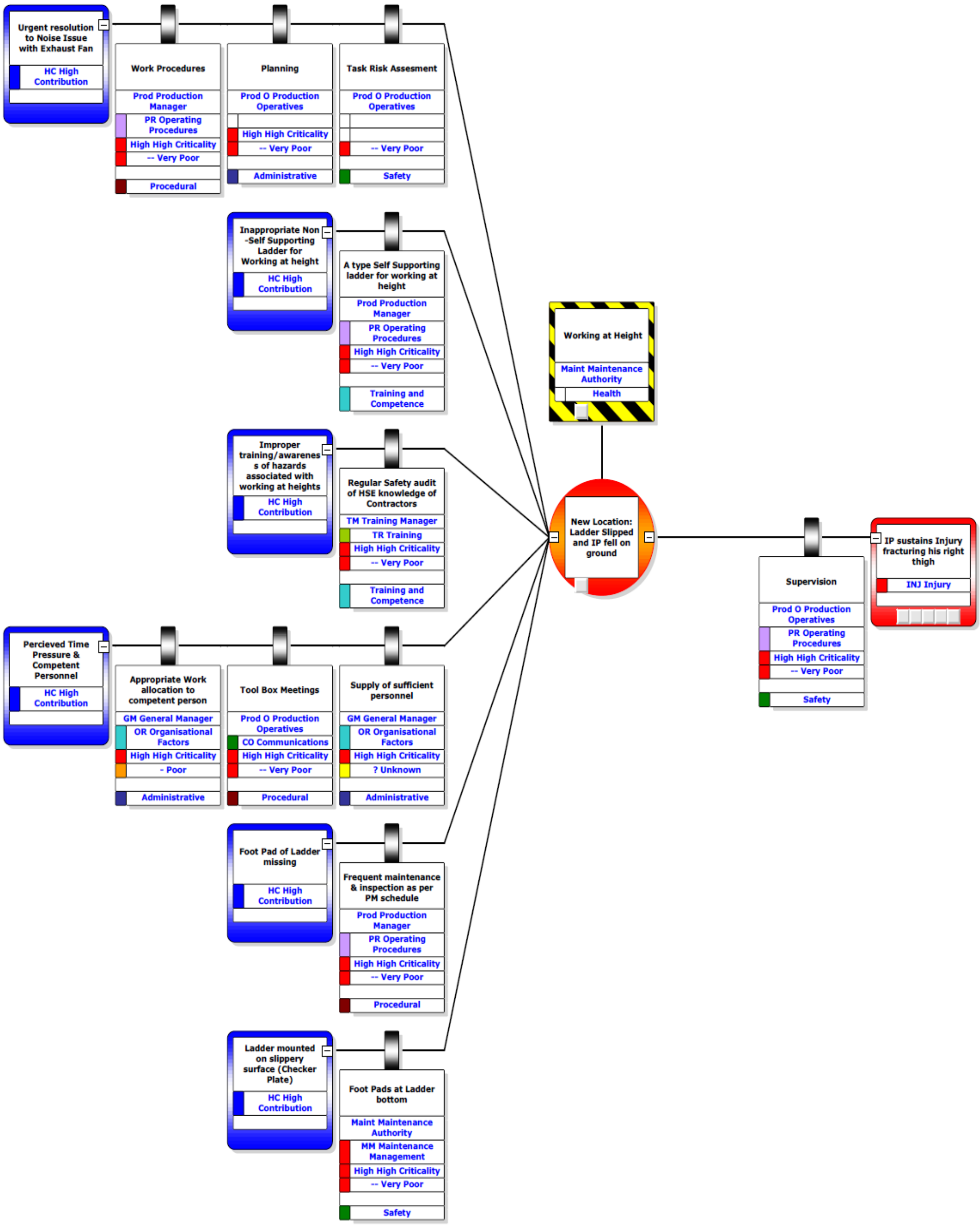


Figure 43: BSCAT analysis coupled with Bow-tie for the accident case study

BSCAT analysis coupled with Bow-tie for the accident case study is depicted above.

3.4.7 Improved model suggested:

Based on number of accident investigation analysis and applying the various tools, it is arrived that barrier based safety analytical tool is more appropriate for identifying the root causes. It is also giving the way to understand why a particular barrier failed and how one can fix the problem to prevent reoccurrence of the incident.

The improved method suggested is to focus more on human behaviour analysis in addition to system failures. As the majority of the accident occurring is attributed to human failure and attitudes are the root causes, it is proposed to introduce attitude factor while analysing the human failure.

The factor constitutes the age of the person, behavioural factor, number of years of experience in the same field, work environmental condition (ergonomics), fatigue factor. The scale for the above parameters assigned are 1 to 5. The factors varies from young age group of personnel to old age (>50 years) group of personnel. The attitudes of group of personnel in the same work environment to be determined and derive the factor. This will vary for different work environment. A person of age group between 20-30 years performing a drilling activity possess high risk than that of a person belongs to age group >30.

This model accommodates the Oil and Gas (Upstream) accidents caused by process hazards and human and Organisational factors effectively with systematic risk assessment and qualitative outputs.

This model utilises existing data (age of the person, experience in the specific task, work environmental conditions, fatigue, shift patterns etc.,) and provides the output to predict the risk. This helps in preventing the accidents in Oil and Gas (upstream).

The Attitude Barrier Model (ABM) represented as follows:

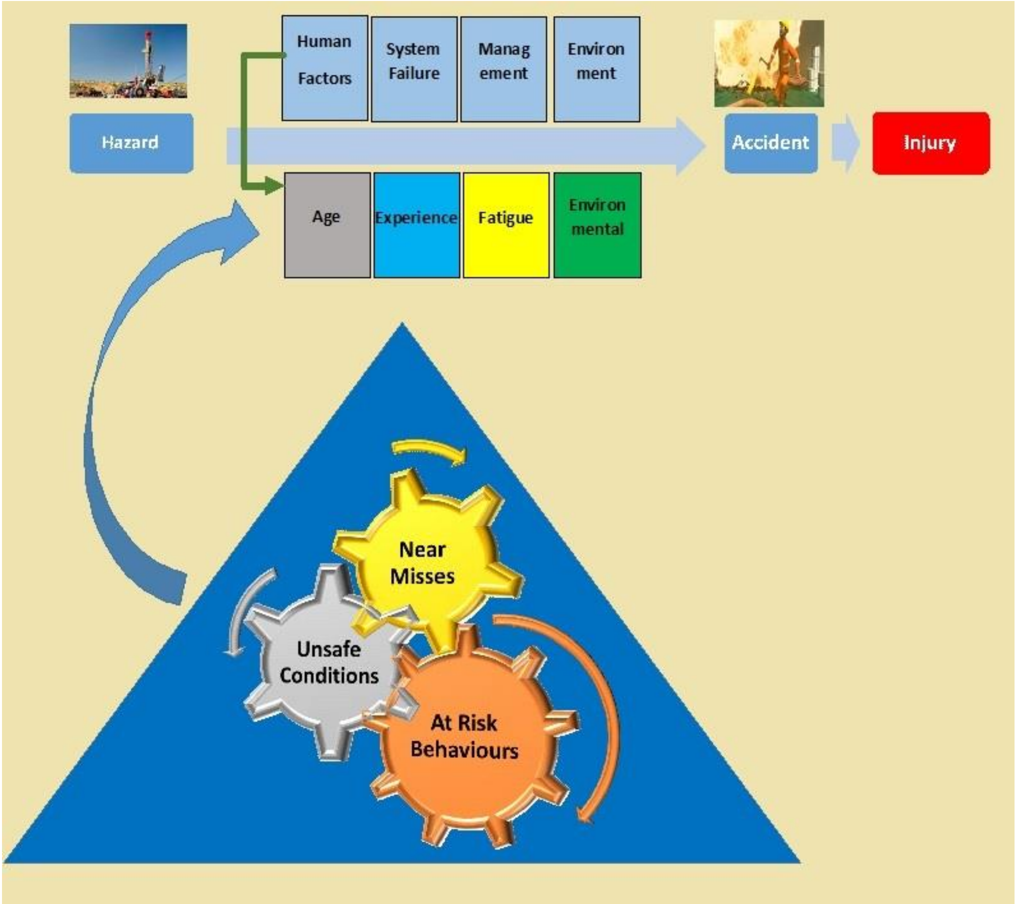


Figure 44: Attitude Barrier Model (ABM)

175 serious injuries (Lost time cases and Medical treatment cases) and 190 First aid cases were subjected to the above model. It is observed that accident occurring in Oil and Gas (Upstream) is complex one. However, the human factors associated with work patterns, age and experience are influencing the barriers.

3.4.8 Attitude Barrier Model Risk Matrix

A risk assessment matrix is proposed based on the human factors contributing for the accident occurrence. It will identify the magnitude of the personal risks due to four factors including persons' age, experience in the particular task, working environmental factors and fatigue. These elements are further assigned with probable contributing factors. Based on the quantification the final risk is categorised into Low, medium and high risk. The resultant risk helps the Oil and Gas installation to plan for appropriate mitigation methods in preventing accidents.

Table 9: ABM-Risk Matrix

Risk elements ↓	***Risk Range*** →		
	Low Risk (1-80)	***Medium Risk*** (81-255)	***High Risk*** (256-625)
Age of the employee			
Experience of the employee in particular task			
Work Environmental condition			
Fatigue			

Table 10: Risk criteria for person's age

Age of the employee	Human Risk Factor
18-25	10
26-35	7
36-45	5
46-55	3
>55	1

Table: 10 The Risk criteria for person's experience in the particular task.

Experience of the person on the task	Human Risk Factor
0	10
1-3	7
4-10	5
11-15	3
>16	1

Table 11: The Risk criteria for person's task related Environmental conditions

Work Environmental Condition	Human Risk Factor
Good Ergonomic condition and Social condition.	1
Poor Ergonomic Condition (difficult for the personnel movement, no proper access etc.,)	2
Poor hygienic conditions (No work place hygiene, no rest rooms, no wash rooms. Poor canteen facility etc.,)	3
Occupational hazards includes high noise, irritating odours, toxic gas presence etc.,	4
Extreme weather condition including cold, hot and humid	5

Table 12: Risk Criteria for the persons Fatigue

Elements of fatigue	Human Risk Factor
Employee to perform the task less than the planned time with less effort	1
Employee to perform the task most of the time in an orderly manged shifts or fixed timing.	2
Irregular job timings and work patterns	3
Employee to perform uncertain work pattern more or continuous shift work more night shifts Most of the time away from family.	4

Stress due to : **Repetitive work** **No change in work patterns like manual handling** **Work including excessive physical involvement** **A combination of any two factors to be classified under this category**	5

While using the above model the method to be followed for computing the risk is:

If a person of age 24 having no experience in the said task and to perform in extreme weather conditions and likely fatigue factor the risk would be:

5 x 5 x 5 x4 = 500. Therefore this situation to be considered under “high risk” and accordingly risk mitigation measures to be adopted for prevention of work place injuries.

If the person of age 50 years and having experience in specific task, Good Environmental working conditions, no risk from ergonomic conditions and less fatigue, the risk estimated to be:

3 x 3 x 1 x 1 = 9. Therefore this situation to be considered under “Low Risk”.

3.4.9 RESULT

- To identify root causes of an incident many analytical tools are available. Each tool is having its own limitations.
- These tools often fail to provide the true underlying causes. These advanced tools depend on the specialist's judgement doing the analysis.
- Failure of human factor quotient to be considered in analysing the accidents.
- The Attitude Barrier Model (ABM) is useful in analysing of major accident in respect to contribution of human factor. The ABM Risk matrix provides detailed human factors influences on accident occurring and thus mitigating the same helps in prevention of work place injuries.

3.5 RECOMMENDATIONS

- Recognize that Oil & Gas Industry accident patterns are different compared to other industries.
- Oil & Gas Management to focus on inherent safety.
- Importance to be given to identification of hazards, Safety barriers and human factor
- Oil & Gas industries to evaluate specific safety promotional programs addressing, Consistent Behavioural interventions to prevent the work place injuries.
- Near miss are significant part of accident occurring.
- Oil & Gas Industry to recognizing that nearmis incidents are part of accident occurring. Therefore, emphasis to be given to analyse.
- Oil & Gas Industry to design Behavioural intervention programs specific to their activities.
- Industry may adopt the Attitude Barrier Model (ABM) while evaluating the root causes.
- Industry to promote safety culture of identifying the human factors as core component of major hazard accident.

CHAPTER 4.
REVIEW OF LITERATURE

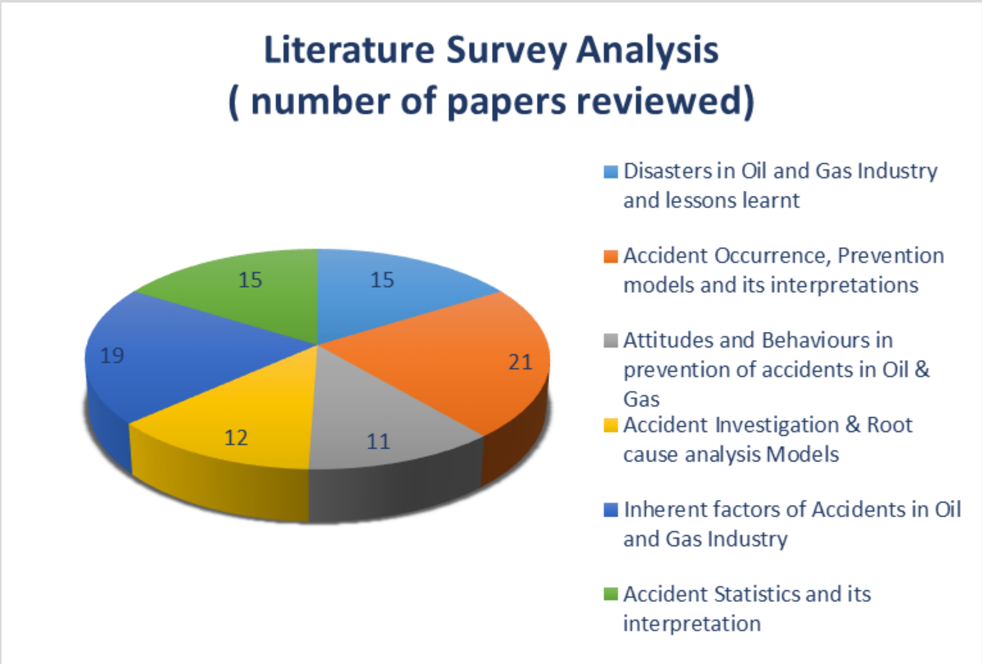
The chapter discusses existing literature available in the similar and allied areas. Literature was reviewed under broad relevant heads and the inferences are recorded briefly under each category. It is evident from the literature that human attitudes are directly related to major accidents in Oil and gas. The interpretation of Heinrich theory of accident occurring to be relooked for Oil and Gas accidents. .

4.1 GENERAL

Literature review carried out under the following broad categories. Summary of inferences from literature review is given under each category.

Category	Number of references
Disasters in Oil and Gas Industry and lessons learnt	13
Accident Occurrence, Prevention models and its interpretations	16
Attitudes and Behaviours in prevention of accidents in Oil & Gas	10
Accident Investigation & Root cause analysis Models	13
Inherent factors of Accidents in Oil and Gas Industry	17
Accident Analysis and its interpretation	16

Table 11: Analysis of Literature survey categories



Graph 23: Analysis of Literature Survey Analysis

4.2 DISASTERS IN OIL AND GAS INDUSTRY AND LESSONS LEARNT

Following documents are reviewed under the category of Disasters in Oil and Gas Industry and lessons learnt

- The Bunce field Incident 11 December 2005. The final report of the MIIB. [12]
- The Bhopal Tragedy, Westview Press, Boulder, Colo.1989. [13]
- Deepwater Horizon accident investigation report. Houston [15]
- A Case Study on Blowout and its Controls in Krishna-Godavari Basin, East Coast of India: Safety and Environmental Perspective [19]
- Deepwater Horizon Oil Spill [21]
- Kletz, T., 2001. Learning from Accidents. Third edition. ISBN 0 7506 4883 X, Gulf Professional Publishing. UK [45]
- Kletz, T, 1991. An Engineers View of Human Error, Third Edition. ISBN 10-1560329106.
- Major Accident Investigation Brach: Research/Offshore Blowout Database.

- National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, "Report to the President", January 2011 [53]
- Trevor Kletz, What Went Wrong? Case Histories of Process Plant Disasters and how they could have been avoided, Fifth Edition.[77]
- US Chemical Safety and Hazard Investigation Board, 2007. Investigation report Refinery Explosion and Fire BP Texas City March 23 2005. Report No. 2005-04-I-TX, March 2007 [79]

From overall review of the literature the low probability high impact incidents are serious concern in Oil and Gas upstream industry. Failure to ensure the barriers is one of the cause for disasters in Oil & Gas Industry. Failure of human factors is the core element in the barrier failure process.

According to the internal incident investigation report [15] by BP incident investigation team who conducted interviews, narrated that it is a well integrity failure, followed by a loss of hydrostatic control of the well. This was followed by a failure to control the flow from the well with the BOP equipment, which allowed the release and subsequent ignition of hydrocarbon. It is a sequence of failure of barriers.

Jain &Yerramilli (2012) in their study 'A Case Study of Blow out and its control in Krishna-Godavari (KG) Basin, East Coast of India: Safety and Environmental Perspective' explained about the major blow outs occurred in KG basin and resulted the number of risks in the relation to the loss of human lives and material assets, environment pollution due to the geological complexity of the wells at Amalapuram, Razole and Narsapur have led to major disasters. In the study they made an attempt to identify the most possible causes of these disasters and proposed a safe drilling procedure to prevent these disasters in the upcoming ventures. They recommended efficient drilling and safety procedures to prevent further blow outs in the future and suggested the utmost importance for oil and gas operators and service companies to take necessary steps in future drilling operations in over pressured formations of KG basin to prevent loss to personnel, property and damage to the environment

The blow out disasters in the region of Krishna Godavari basic, left a trail of destruction in the area, and there was heavy damage to the flora and fauna. The prevention of anthropogenic hazard lies in the hands of the operators and their personnel. The combination of hazard consciousness management, efficient and reliable equipment and well educated and trained officials are the best options for anthropogenic hazard prevention and to avoid environmental damage.

4.3 ACCIDENT OCCURRENCE, PREVENTION MODELS AND ITS INTERPRETATIONS

The following relevant research works have been reviewed in accident occurrence and various models.

- Accident Prevention manual for business & Industry: administration and programs [1]
- Industrial Accidents: A symptom of an environmental problem [2]
- The Heinrich accident triangle: Too simplistic a model for HSE Management in 21 century [6]
- On the prevention of accidents and injuries. A comparative analysis of conceptual frameworks. Accident Analysis and Prevention [7]
- A system of safety management practices and worker engagement for reducing and preventing accidents: an empirical and theoretical investigation [8]
- Models for problem solving in Health and Safety[9]
- Preventing Serious Injuries & Fatalities [25]
- Foundation of Major Injury, Adapted from Industrial accident prevention [31]
- Heinrich, Industrial Accident Prevention [35]
- Keeping People Safe: The Human Dynamics of Injury Prevention [39]

- Prevention of Accidents Through Experience Feedback [41]
- Occupational accident research and systems approach [45]
- Heinrich revisited: Truisms or myths [49]
- Reviewing Heinrich: dislodging two myths from the practice of safety [50]
- A principled basis for accident prevention [60]
- Graphic representation of accident scenarios: mapping system structure and the causation of accidents [76]

The accident occurrence patterns are different in Oil & Gas against the patterns most of the companies followed. Heinrich concept of accident occurring theory might be relevant for the other process industries but not Oil and Gas Industry. There is no evidence from the literature survey that Heinrich considered the Oil and Gas industrial accident.

As discussed by Ali Al-Shanini et.al in *Accident modelling and analysis in process Industries,* Heinrich concept of accidents are outcome of a chain of discrete events that are taken place in a temporal order. Domino theory describes accident sequence as a chain of five discrete events or factors (social environmental, fault of person, unsafe acts or conditions, accident, injury) that if the first factor falls, the four other factors will fall in a domino.
Human failure was the only one considered factor whereas other failure such as process, management and organizational were not. It is a liner model that regards accident causal as a result of single cause rather than multi-causes of nonlinear as in real life.

Swiss cheese model of defence (Reason's model), the events, in this model, are propagation in same analogous as disease spreading. In Swiss cheese model; procedure, human and material protection barriers were introduced, and how they fail, as well how organizational factor affects these barriers was asserted. In this model, the accident cause-which can be either immediate or proximal cause-is regarded as people fault either who is involved in the process or interacting with the processes technology (Reason, 1990).

Swiss cheese models is having the limitations including it is a linear causation model, the causality that links the organizational conditions and accident consequence is complex and qualitative model with no mathematical representation.

The near-misses are important in prevention of major accidents. However the reporting of the same found to be a concern.

4.4 ATTITUDES AND BEHAVIOURS IN PREVENTION OF ACCIDENTS IN OIL & GAS

The following reference documents were reviewed during literature survey relevant to the above objective

Faridia Ismail, et.al (2012) discussed in their research paper that Observation, intervention, review and monitor are the key components of Behavioural safety changes at work place. The approach is able to minimise the accidents, change unsafe behaviours and improve Quality and safety environment.
Behavioural safety does improve safety behaviour and reduce injuries based on the studies reviewed. BBS is an analytical or data-driven approached, where critical behaviour get identified and targeted for change.

Monazzam Mr, and Soltanzadeh A. (2009), discussed in their article 'The Relationship between the Workers' Safety Attitude and the Registered Accidents illustrated that the relationship between safety attitude of the workers and accidents occurred was significant.

- Behaviour change versus culture change: divergent approaches to managing workplace safety [23]
- Preventing serious injuries and fatalities [26]
- Managing safety: an attitudinal-based approach to improving safety in organisations [27]

- Behavioural Based Approach for Quality and Safety Environmental Improvements: Malaysian experience in Oil and Gas Industry [28]
- Industrial Safety and Human Behaviour [36]
- The Relationship between the workers Safety Attitude and the Registered Accidents [51]
- Normal Accidents: Living with High-Risk Technology [57]
- Human Error [61]
- Safety Culture and Behavioural change at work place [65]
- An explicative model of unsafe work behaviour [67]

4.5 ACCIDENT INVESTIGATION & ROOT CAUSE ANALYSIS MODELS

The following research works were referred for the Accident Investigation and root cause analysis models.

Many models are in practice for analysing the accident that have occurred. However, BSCAT software helps the analysis of accidents and findings the root causes more accurately.

- Models for Problem solving in Health and Safety, Safety Science Vol.15[9]
- Development of an working model of Human Factors, Safety Management Systems and wider Organisational issues fit together.[10]
- Accident Investigation: Multilinear events sequencing methods [11]
- BowTieXP, The next Generation Bow-tie Methodology Tool [14]
- Layer of Protection Analysis-Simplified Process Risk Assessment [18]
- DNV-BSCAT, Built on the BowTieXP platform Software Manual [24]
- Modern accident Investigation and analysis: An executive guide [29]
- Modern Accident Investigation and Analysis (2nd ed,WILEY Inter Science Publication, US)[30]
- Investigating accidents with STEP [35]

- Accident and Accident Analysis based on Accident evaluation and barrier function model[84]
- Two methods for accident analysis: comparing human information processing with an accident evolution approach[85]
- Accident analysis and risk control, Dereck-Viner pty ltd, Mel born, 1991.

4.6 INHERENT FACTORS OF ACCIDENTS IN OIL AND GAS INDUSTRY

The accident occurring patterns are influenced by several human factors including their work patterns, age, environmental working conditions and duration of Occupational exposure.

Cooper, C.L and Sutherland, V.J. discussed in their research work [20] that nature of stress various among working crew. The work related stress is having significant impact on accident occurring. Therefore, respective Operators to target the elimination of source of stress and design stress control programs accordingly. It is suggested to conduct a stress audit aiming to understand the human behaviour in a particular working environment. It shall address the potential sources of stress, assess which of the sources of stress have the greatest negative impact.

Potential sources of stress in the offshore oil and gas industry to be identified. The technique known as “factor analysis” used to identify common patterns, known as ‘stress factors’. Few stressor items listed as follows:

Career prospects and reward includes lack of job security, lack of training opportunities, the business has changed, it’s not what it was, and Safety training courses are not updated regularly enough and no recognition for doing a good job.

Safety and insecurity at work covered poor working relationships on the installation, inconsistent / unpredictable workload, inadequate instructions to do the job, having a near-miss accident.

Physical conditions-working and living includes unpleasant working conditions due to vibration, noise and cold, disturbance in living accommodation due to vibration, noise from machinery, noise from other people, and heat and cold.

Unpredictability of work pattern viz., last-minute change in crew relief arrangements or relief delayed, short notice recall to rig etc.
Living conditions are inadequate leisure facilities to occupy free time, sharing living and sleeping accommodations, inadequate facilities for physical exercise and lack of privacy.

Physical climate and work are feeling unsafe in bad weather, working in a hazardous or dangerous environment.

Work overload includes pay cuts due to the recession, working excessive periods of time offshore with only a short break between trips.

As per research report RR772 prepared by the University of Oxford "Offshore working time in relation to performance, health and safety":

The most frequently reported psychosomatic complaints in 1990 survey of Norwegian Offshore workers (Laurites et.al 1991) were headaches, stomach problems and muscular tensions but the incidents of these complaints varied across shift patterns and occupational groups. Stomach problems were particularly associated with rotating day/night shift work. A further study of psychosomatic problems offshore evaluated the independent effect of shift patterns and occupational group. The results shown the clear pattern: Day/Night shift work as compared with Day work, was associated with sleep problem and gastric problems, while the incidence of headaches, musculoskeletal problems, injuries and psychological symptoms differed across job types.

Poor sleep quality and accumulated sleep deficits intern give rise to fatigue and to impairments of subjective alertness and performance, their by increasing the likelihood of error, and consequently the risk of accidents and injury.

A recent review of research into extended work shifts and overtime in onshore work settings identifies adverse effects on illness, injury, health behaviours and cognitive function. Concern about long work hours are particularly acute in relation to offshore managers and supervisors whose work hours are not subject to formal regulation.

- Driver fatigue, Human Factors [16]
- Dynamic Decision Making: Human Control of Complex Systems [17]
- Job stress, mental health, and accidents among offshore workers in the oil and gas extraction industries [20]
- The Field Guide to Understanding Human Error [22]
- A shift schedule of seven nights followed by seven days in offshore installation workers. [32]
- Risk factors and risk reduction strategies associated with night work with the focus on extended work periods and work time arrangement within the petroleum industry in Norway [34]
- Industrial Safety and Human Behaviour, H L Kaila[37]
- Offshore Industry shift work health and social consideration, Occupational Medicine, Vol. 59[43]
- Kletz T, An Engineers View of Human Error, 3rd Edition[47]
- Health disorders of shift workers[49]
- Decreased rate of back injuries through wellness programs[54]
- Critical steps: managing the human risks [58]
- Shift work, job type and the work environment as joint predictors of health related outcomes[62]

- The significance of shift work: current status and future directions [65]
- Human Error, Cambridge University Press, UK[70]
- Job engagement: antecedents effects on job performance, The Academy of Management Journal 53[73]
- Work schedule and task factors in upper-extremity fatigue. Human factors.[74]
- Smit P A, Wedderburn AAI, Flexibility and long shifts[80]
- The impact of work schedule on the egalitarianism/life satisfaction model[93]

4.7 ACCIDENT ANALYSIS AND ITS INTERPRETATION

Benchmarking reports of Oil & Gas Installations published by IOGP were reviewed for three consecutive years. There are 51 companies participated in the benchmarking study consistently.

The 2015 IOGP Safety Performance Indicators shows that the Fatal Accident Rate for reporting companies has increased by 41% compared with 2014. The number of fatalities has increased from 45 in 2014 to 54 in 2015.
The most common causal factor for fatal incidents found to be people not following the procedures and taking improper position (line of fire).

The interpretations are:
The Fatal accident rates are reducing in the Oil & Gas Industry. However, fatal accidents are caused because of unsafe behaviours or failure to follow basic safety rules at work site. Personnel often found missing to recognise the hazards and thus accidents are resulting.

- Strategies in Health and Safety at work, The Production Engineer, Vol.54[3]
- Review of High Cost Chemical/Petro Chemical Accidents since Flixborough 1947 by P Fuwtrell[4]

- A Study in the Oil & Gas Industry in Denmark, Safety Science Monitor, Vol. 17[33]
- International Association of Oil & Gas Producers (IOGP), report 2014S, June 2015, Safety Performance Indicators 2014 [38]
- International Association of Oil & Gas Producers (IOGP), report 2015S, June 2016, Safety Performance Indicators 2015 [39]
- Occupational Accident Research and Systems approach[50]
- Applying STAMP in Accident Analysis[51]
- Injuries on offshore Oil and gas installation: An analysis of temporal and occupational factors [63]
- Human error and the problem of causality in analysis of accidents [68]
- A review on accident pyramid and its empirical interpretation in Oil and Gas Industry.[78]
- Sustainability Report-Cairn India-FY 2013-14[81]
- Sustainability Report-Cairn India-FY 2014-15[82]
- Nearmis Reporting in the Chemical Process Industry[89]
- WOAD: World Offshore Accident Data bank (DNV)[92]

4.8 SUMMARY

It is evident from the literature that Oil & Gas Operations are posing high risk to personnel, environment and the assets. The pattern of accident occurring in Oil & Gas industry to be viewed differently than the traditional accident occurrence theories. Failure of barriers are the causes of Oil & Gas accidents. These primarily attributed to the failure of personnel adhere to the procedures or human behaviours.

Inherent human factors including fatigue, work patterns, shift work patterns, stress, unpredictability of work patterns, living conditions and work overload are influencing the accidents.

The oil and gas industry can improve its overall safety performance for low-probability high-consequence events by working at a global sector level, or even globally across the industry by better sharing of the right kind of information on incidents.

The technical failures vary from one accident to another but the organisational failures which accident analyses reveal seem remarkably similar. A focus on organisational rather than technical causes therefore offers the best opportunity for generalisation, that is, the best opportunity for types of learning that can be transferred from one enterprise or industry to another.

A safer design of Oil & Gas installations and risk mitigation measures to be focused.

Near-misses are often not reported and information about them remains "hidden". As a result, for certain types of units we often have more accidents than near-misses, which is contrary to the "pyramid" of accidental events.

Offshore accidents are not extremely rare events. In particular, blowouts with severe consequences may not be as rare as initially thought. Further investigation of these events is necessary.

CHAPTER 5.
CONCLUSION AND CONTRIBUTION

The chapter concludes current research work and noticeable contributions are mentioned in this section. Recommendations of the research and the benefits in implementing research finding to all stakeholders of business are given in this section. Also, scope for future research was outlined at the end of this chapter.

5.1 SUMMARY

Oil and Gas (Upstream- construction, Operation and maintenance of Drilling, production and associated facilities) activities are involved with high safety risks. Low probability high impact incidents continued to cause significant human loss, environmental damage and asset losses. Several factors involved in accident causation in Oil& Gas. However, the nature of operations adding additional risks such as failure to identify the specific hazards at work place, age and experience of the personnel involved in the Operations, shift work patterns and other environmental conditions are key components in accident occurring in Oil& Gas Upstream operations. The industry continued to follow the accident occurring theory of Heinrich (1:30:300). However, from the research analysis the Industry to consider further more casual factors of accident occurring.

Human attitudes are having direct relation with serious accidents. Therefore a systematic and consistent behavioural interventions restrain the personnel from “at risk behaviours”.

Fatal injuries in Oil & Gas Upstream could be minimised and achieve “zero accident” level by consistently practicing the basic safety lifesaving behaviours.

Oil and Gas Organisation to encourage promoting hazards identification by each individual and emphasis on ensuring effective barriers for each task.

Though many accident analysis models are in use, the detailed analysis of barriers and its specific failures are having significant importance in understanding the causes of the accidents. The bow-tie method of identifying the barriers and evaluating their effectiveness and BSCAT integration of further analysing the barriers are the advanced techniques helps the Oil & Gas Upstream accident analysis.

5.2 CONCLUSION AND NOTICEABLE CONTRIBUTIONS

5.2.1 Patterns of Accidents in Oil & Gas

Low probability high impact incidents are causing loss of human, environment and assets in Oil & Gas Upstream Industry. Failure to identify the weaknesses in the safety barriers are the most likely causes of the accidents.

There is a difference in accident patterns that are occurring in Oil and Gas Upstream when interpreting the Heinrich theory of accident occurring. Heinrich in his theory might have not considered the Oil & Gas work environment with different kind of hazards and risks. Therefore Oil & Gas Upstream industry to consider that accident patterns are different and infuse their safety management systems accordingly for prevention of accidents.

5.2.2 Accident Patterns in Cairn India

The accident patterns are similar to other Oil & Gas Upstream Industry. However, the patterns are differed from the Heinrich theory of accident occurring.
Drilling activity is the major contributors for serious accidents occurring in Cairn India. This could be attributed to aligning various contractors for the local environmental conditions and lack of compliance to basic safety controls. Type of accidents surfaced from fall from height, caught between, slip & trip, Struck by category which are same as other Oil and Gas Upstream industry type of accidents.

Personnel between age group of 20-30 years found to be vulnerable for work place injuries. Hence the Oil and Gas (Upstream) facilities to recognise the risk prior to deployment of such group of personnel and also to consider to instil behavioural motivation processes to prevent work place injuries.

5.2.3 Inherent Risk Factors including Human Attitudes

Personnel coming under line of fire, failure to identify hazards at work place, improper lifting, lack of skill and lack of supervisory competency are major factors found in accidents patterns. This inference results in detailed understanding of accident patterns in Oil & Gas Upstream Industry.

Therefore Oil & Gas Up stream industries to focus on inherent risk factors in prevention of work place injuries.

5.2.4 Methodologies of Accident Root-cause analysis

After verifying various accident analysis models, it is important to identify the barriers that have failed and lead to an accident which results in human injury. It is further important to identify strength and weakness of each barrier.
The bow-tie method coupled with BSCAT analysis of accident occurring is having advantage in analysis of accidents in Oil & Gas Upstream Industry.

5.3 ADVANTAGES

Following advantages are expected from the implementation of research recommendations.

- Understanding about the underlining cause of major accidents occurrence. Oil and Gas Operations to recognise low probability and high impact incidents are associated with human behaviours. Therefore identification of weak links including human factors will reduce the probability of accidents.
- Re interpretation of Heinrich theory of accident theory of accident occurrence prompting to recognise accident occurrence in Oil & Gas Upstream are different pattern.
- As drilling activity related accident are more, controls to be reemphasised to minimise the accidents.
- As the age group of 20-30 years found vulnerable for accidents, specific human risk controls measures could be incorporated much before allowing the personnel to work at Oil and Gas Upstream. It will contribute in elimination or prevention of accidents.
- Attitudes are directly related to accident occurring.
- Consistent behavioural interventions preventing the work place injuries. Therefore, if the Oil & Gas Upstream adopts necessary intervention methods it can reduce the work place injuries.
- Failure of human factor quotient to be considered in analysing the accidents.

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- Using the attitude barrier model (ABM) provides opportunity to incorporate human factor including fatigue, age factor, experience of the person and other work environmental conditions.
- Considering the advantages listed in the previous section (5.7.1, 5.7.2, 5.7.3 and 5.7.4) the work place injuries significantly be reduced.
- This research inference greatly helps in reduction of accidents in Oil & Gas Upstream industry and thus helps in sustainable business.

CHAPTER 6.
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Appendix and Supporting Documents.

In this chapter, additional material that supports current research work is given for cross references :

1. Definitions used in the thesis by the Research Scholar- Appendix#01
2. The research papers published by the scholar during the research period.
   - 2.1 A Review on Accident Pyramid and its Empirical Interpretation in Oil & Gas Industry (Upstream)- Appendix#02
   - 2.2 Role of Near-misses and Behavioral Patterns in Preventing Work Place Injuries (Oil & Gas -Upstream)-Appendix#03
   - 2.3 Influence of Inherent Human Factors at Work Place Safety in Oil & Gas (Upstream) –Under Publication.
3. Curriculum Vitae of the Research Scholar-Appendix#04

Appendix# 01

DEFINITIONS

Caught in, Under or Between (As an Incident / Event Category)

Injury where injured person is crushed or similarly injured between machinery moving parts or other objects, caught between rolling tubulars or objects being moved, crushed between a ship and a dock , or similar incident. Also includes vehicle incidents involving a roll over.

Construction (As a Work Function)

Major construction, fabrication activities and also disassembly, removal and disposal decommissioning at the end of the facility life.

Contractor Employee

Any person employed by a contractor or contractor's sub-contractor who is directly involved in execution of prescribed work under a contract with the reporting company.

Cut, Puncture, Scrape (As an Incident / Event Category)

Abrasion, scratches and wounds that penetrate the skin.

First Aid Case (FAC)

Cases that are not sufficiently seriously to be reported as medical treatment or other serious cases but nevertheless require minor first aid treatment, e.g. dressing on a minor cut, removal of a splinter from a finger. First Aid cases are not recordable incidents.

Lost Work Days (LWDC)

Any work related injury or illness, other than a fatal injury, which results in a person being unfit for work on any day other than the day of occurrence of the occupational injury. “Any day” includes next work day, weekend days, leave days, public holidays or day after ceasing employment.

Medical Treatment Case (MTC)

Cases that are not severe enough to be reported as fatalities or lost work day cases or restricted work day case but are more severe than requiring simple first aid treatment.

Restricted Work Day Case (RWDC)

Any work related injury other than a fatality or lost work day case which results in a person being unfit for full performance of the regular job on any day after the occupational injury

Falls from Height

A person falls from one level to another.

Fatal Accident Rate (FAR)

The number of fatalities per 100,000,000 (100 million man hours)

Hours Worked

The actual “Hours Worked” including overtime hours, are recorded in the case of on shore operation**.** The hours worked by an individual will generally be about 2000 per year.

For off shore workers “the Hours Worded” are calculated on a 12 hours work day. Consequently average hours worked per year will vary from 1600 to2600 hours per person depending upon the on/off shift ratio.

Incident

An unplanned or uncontrolled event or chain of events that has resulted in at least one fatality, recordable injury, or physical or environmental damage.

Drilling (As a Work Function)

All exploration, appraisal and production drilling and work over as well as their administrative, engineering, construction, materials supply and transportation aspects. It includes site preparation, rigging up and down, and restoration of the drilling site upon work completion.

Drilling / Workover/ Well Services (As a type of Activity)

Activities involving the development, maintenance work or remedial treatments related to an oil or gas well.

Event

An unplanned or uncontrolled outcome of a business operation or activity that has or could have contributed to an injury or physical damage or environmental damage.

Exploration (As a Work Function)

Geo physical, seismographic, geological operations including their administrative and engineering aspects, construction, maintenance, material supply and transportation of personnel and equipment; excludes drilling

Lost Time Injury (LTI)

A fatality or lost work day case. The number of LTIs is the sum of fatalities and lost workday cases.

Lost Time Injury Frequency (LTIF)

The number of lost time injuries (fatalities + lost work day cases) per/1,000,000 work hours.

Near miss

An unplanned or uncontrolled event or chain of events that has not resulted in recordable injury or physical damage or environmental damage but had the potential to do so in other circumstances.

Number of lost work days

The sum total of calendar days (consecutive or otherwise) after the days on which the occupational injury occurred, where the persons are involved were unfit for work and did not work.

Occupational Illness

Any abnormal condition or disorder, or any fatality other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. Occupational illness may be caused by inhalation, absorption, ingestion of, or direct contact with the hazard, as well as exposure to physical and psychological hazards. It will generally result from prolonged or repeated exposure.

Occupational Injury

Any injury such as a cut, facture, sprain, amputation etc., or any fatality, which results from a work related activity or from an exposure involving a single incident in the work environment such as deafness from explosion, one time chemical exposure, back disorder from slip/trip, insect or snake bite.

Offshore work

All activities and operations that take places at sea, including activities in bays, in major inland seas, such as Caspian sea, in other inland seas directly connected to oceans. Incidents including transportation of people and equipment from shore to the offshore location, either by vessel or by helicopter should be recorded as "Offshore work"

Onshore work

All activities and operations that take place within a land mass, including those on swamps, rivers and lakes. Land to land aircraft operations are counted as Onshore, even though flights are over water.

Production (as a work function)

Petroleum and natural gas producing operations, including their administrative and engineering aspects, minor construction, repairs, maintenance and servicing, material supply, and transportation of personnel and equipment. It covers all main stream production operations including wire line. Gas processing activities with a primary intent of producing gas liquids for sale including: Secondary liquid separation and liquefied natural gas operations.

Production Operations (as a type of activity)

Activities related to the extraction of hydrocarbons from sources such as an Oil or Gas well or hydrocarbon bearing geological structure, including primary processing, storage and transport operations. Includes normal, start up or shut down operations.

Seismic / survey operations (as a type of activity)

Activities relating to the determination of sub-surface structures for the purpose of locating the Oil & Gas deposits including geophysical and seismic data acquisition.

Slips and trips (at the same height) (as an incident/event category)

Slips, trips and falls cost by falling over or onto something at the same height.

Struck by (as an incident /event category)

Incident / events where injury results from being hit by moving equipment and machinery, or by flying or falling objects. Also includes vehicle incidents where the vehicle is struck by or struck against another object

Total recordable incidents

The sum of fatalities, lost work day cases, restricted work day cases and medical treatment cases.

Transport-Land (as a type of activity)

Involving motorized vehicles, designed for transporting people and goods over land, example, cars, buses, trucks. Pedestrians struck by a vehicle are classified as land transport incidents. Incidents from a mobile crane would also be land transport incident if the crane were being moved between.

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A Review on Accident Pyramid and its Empirical Interpretation in Oil & Gas Industry (Upstream)

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Abstract- Accident prevention is the key in effective Health, Safety and Environmental management system of any Organization. Understanding the pattern of accidents and ratios helps in preventing major accidents. The older theories on accident prevention have influenced the safety professionals to design accident prevention programs. However, over a period of time, rapid growth in industrials activities are challenging the theories. Hazards are different for different industries and hence resultant safety risks are not uniform. A need arisen to further review and interpret the accident patterns. This paper focused on reviewing and highlighting the gaps in interpretation of accident triangles with respect to Oil and Gas (upstream). How the Oil and Gas is interpreting the accident occurrence and evolving with preventive measures.

Index Terms- Accidents, Accident Triangle, Oil & Gas (Upstream), accident prevention, Process Safety Incidents.

I. Introduction

An accident may be defined as an unexpected and unplanned occurrence, which may or may not involve injury. The possibility of an accident occurring is present in every sphere of human life.

Accident triangle prescribed by Bird (1969) and Tye and Pearson (1974/75) on accident rations were in practices. It has provided a support to safety professions to draw a road map in preventing accidents. Bird's work was based in turn on earlier work by Herbert William Heinrich in the 1920, published and republished from 1932 to 1959 in his book Industrial Accident Prevention: A Scientific Approach.

Three principles based on the accident triangle are:

There are consistently greater number of less serious events than more serious ones.

Many near misses could have become events with more serious consequences.

All the events (not just those causing injuries) represent failures in control, so are potential learning opportunities.

It is evident from various accident prevention theories that accidents do not happen always according to predefined sequences and scenarios. Rather, they – almost always – fail in complex ways and there is a variety of root causes leading each time to the accident. For that reason it is not possible for a prescriptive regulatory framework to address all relevant risks. It is necessary to use the principles of risk assessment and safety management to review and control the risks on a case-by-case basis.

II. Heinrich Accident Pyramid

Herbert William Heinrich (1886- June 22, 1962) was an American industrial safety pioneer from the 1930s. He was an Assistant Superintendent of the Engineering and Inspection Division of Travelers Insurance Company when he published his book Industrial Accident Prevention, A Scientific Approach in 1931. One empirical finding from his 1931 book became known as Heinrich's Law: that in a workplace, for every accident that causes a major injury, there are 29 accidents that cause minor injuries and 300 accidents that cause no injuries. Because many accidents share common root causes, addressing more commonplace accidents that cause no injuries can prevent accidents that cause injuries.

Heinrich's work is claimed as the basis for the theory of Behavior-based safety by some experts of this field, which holds that as many as 95 percent of all workplace accidents are caused by unsafe acts. Heinrich came to this conclusion after reviewing thousands of accident reports completed by supervisors, who generally blamed workers for causing accidents without conducting detailed investigations into the root causes.

While Heinrich's figure that 88 percent of all workplace accidents and injuries/illnesses are caused by "man-failure" is perhaps his most oft-cited conclusion, his book actually encouraged employers to control hazards, not merely focus on worker behaviors. "No matter how strongly the statistical records emphasize personal faults or how imperatively the need for educational activity is shown, no safety procedure is complete or satisfactory that does not provide for the . . . correction or elimination of . . . physical hazards,"

This theory came to be accepted as the norm for occupational safety for many years, and continues to have a major influence on the ways in which executives and leaders think about it. However, modern methods of examining the causes of accidents prove that the safety pyramid is not a valid tool for injury prevention.

III. Accident Pyramids and Safety Culture

Organizations have realized that work place injuries are no more tolerable. However, focus was on reacting for accidents and its corrective actions. A need has arisen to understand the root causes of accidents learn lessons from the past incident and establish a sustainable safety culture. There are four types of safety cultures practiced to achieve "Zero Accidents" at work Place.

- Reactive Culture
- Dependent Culture

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- Independent Culture
- Interdependent culture

For all the above stages to progress, the pattern of accidents, the pyramid structure became vital for emulating accident prevention program.

IV. Accident Data Management in Oil & Gas Industry

Learning lessons from accidents is vital in order to avoid accidents in the future. Knowledge of past accidents serves as important input to risk assessment with respect to hazard identification, consequence evaluation, decision support, and identification of high risk areas.

40-years' experience of worldwide offshore accident history is systemized and stored in DNV GL's Worldwide Offshore Accident Databank - WOAD.

Technical information about approximately 3700 offshore units including mobile drilling unit's location and operation mode at any time is available. This helps the Oil & Gas industry for developing their accident prevention program.

Data on a number of parameters such as name, type and operation mode of the unit involved in the accident, date, geographical location, chain of events, causes and consequences, and evacuation details are available.

International Association of Oil & Gas Producers (OGP) has been collecting the safety incident data since 1985. It is having largest data base of safety performance in E&P Industry. About fifty member Organization of Oil and Gas participate in annual benchmarking process which focuses on accidents and injuries in the sector. The accident pyramids resulted from these comparative studies are different from the Heinrich theory.

2013 incident Triangle of OGP

2012 incident Triangle of OGP

2011 incident Triangle of OGP

These incident triangles of OGP pertinent to three consecutive years helped the Oil & Gas Industry to further design accident prevention programs. It also released Life saving rules (OGP Life saving rules, OGP report no 459) intended for Oil & Gas Industries. It is interpreted that 67% of fatal accidents would have been reduced by implementing life saving rules. These are rules consists of icons with simple text providing simple communication on prevention of accidents. These life saving rules are prepared based on accident data and pyramids in Oil and Gas Industry. There is an increase in work hours by 2% and decrease in fatalities.

V. Summery and Conclusion

Heinrich's Accident pyramid helped the industry to look ahead for prevention of accidents. It has brought an insight to understand the sequence of serious accident occurring and accordingly the Organizations have proactively designed their accident prevention programs. However, rapid and diversified industrial activities, many hazards increased and accordingly the risk of serious accidents increased. The research on post Heinrich proposal suggested to revalidation of the theory and Organization to relook into their specific hazards and risk controls to prevent serious injuries at work place.

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He is having exposure to Oil & Gas, Petroleum Refining, Petrochemicals, Engineering Procurement and Construction Industry and Nuclear fuel processing Industries within India and abroad.

Played a key Health, Safety and Environmental leadership roles in various Organizations
- Reliance Industries
- Bhabha Atomic Research Centre (Atomic Energy of India)
- ISCO, one of the largest EPC company in Kuwait

He is currently with Cairn India limited in Corporate HSE-Excellence leadership role.
Siva Prasad Penkey has several papers on work place safety improvements presented during national and International Conferences. He has carried out work place research on "Participation approach improves work place Health and Safety". Presented a paper in American Congress of Govt. Industrial Hygiene, World Congress held in Anhem, California in the year 2005. He was also active member as Head, Occupational Health and Safety of ASSE Chapter Kuwait. He carried out more than 50 accident investigations. He mentored more than 20 University students for their project works.

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Role of Near-misses and Behavioral Patterns in Preventing Work Place Injuries (Oil & Gas -Upstream)

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Abstract- Business activities of Upstream Oil & Gas Industry are exposed to different kinds of hazards and risks. Along with other fundamental Health, Safety and Environmental Management system in place, human behaviors are ultimately the key factors in preventing accidents. Systematically adopting lifesaving rules and its implementation through behavioral changes brings significant reduction of work place injuries. Management focus on encouraging sustainable behavioral safety culture and deeply investigating the root causes of the incidents including near misses may help to achieve a culture of "accident free work place in Oil & Gas".

This paper describes the role of near-misses and Behavioral interventions in prevention of accidents in upstream work environment. A total of 250 near-misses that have occurred in an upstream Oil & Gas facility were analyzed and about 10000 behavioral Observations were also studied. The outcome of the study indicates that serious work place injuries are having correlation with near-misses and behavioral interventions. Serious injuries are resulting due to over sighting of near-misses and failure to correct the repeat at risk behaviors.

Index Terms- Accidents, Behavioral Safety, interventions, Oil & Gas (Upstream), lifesaving rules, work place safety.

I. Introduction

Oil and Gas Industry is vulnerable for low probability and high impact incidents. However good the Health, Safety, Environmental management systems in place, the human behaviors at work place are ruling the prevention of accidents. Root causes of major accidents attributed as personnel not following the fundamental procedures, poor work place supervision, inadequate training and competence. Further strong reasons are failure to identify hazards and risk assessment.

II. Near-misses and Safety Observations

Near-misses are defined as the incidents have just occurred with a potential to cause serious injury or damage but did not result in.

An event which under slightly different circumstances could have resulted in an injury/damage/loss. Generally such events are unplanned and the consequences are avoided by circumstances. Examples:

Tripped or slipped while walking down the stairs, but held on to some form of support thus avoiding the risk of injury

While lifting a bundle of cable trays using crane, few trays slipped and fell from a height. The rigging crew who were just left the spot have escaped without injury where the trays fell on ground.

Near-misses play a vital role in accident prevention. In the hierarchy of accident occurring pyramid, near-misses takes the bottom of the place. However, they are the significant contributors for a serious accident to occur if they are not analyzed and prevented recurrence of the same.

As per Heinrich's law for every accident that causes a major injury, there are 29 accidents that cause minor injuries and 300 accidents that cause no injuries. These includes Near-misses.

- Therefore if we capture more and more Near-miss events and follow-up with corrective actions, the potential for major injuries / fatalities will get minimized.
- Near misses are smaller in scale, relatively simpler to analyze and easier to resolve. Thus, capturing near misses not only provides an inexpensive means of learning, but also has some equally beneficial spin-offs.
- Near misses provides immense opportunity for "employee participation," a basic requirement for any successful HSE Program.
- Near-miss system creates an open culture whereby everyone shares and contributes in a responsible manner. Near-Miss reporting has been shown to increase employee relationships and encourage teamwork in creating a safer work environment.

Many Organizations do have reporting of near-misses, analysis of near-misses and publish lessons learnt from the same to prevent reoccurrence. However, many research studies indicate that near-miss reports are still not optimally used for learning. One potential barrier is that the definition of a near miss is unclear.

At risk behaviors and unsafe conditions are another set of contributors for accident. However these are fundamentally associated with human behaviors at work place. They are greater in number than the near-misses. Over a period of time, Behavioral changes and self-realization of the personnel at work place, timely interventions, only reduces the incidents. These are the core values of safety culture.

Unsafe practices such as unsafe conditions, unsafe acts are basic causes of accidents. The International Association of Oil & Gas Producers (IOGP), has been collecting safety incident data from its member companies globally since 1985. The data

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collected are entered into the IOGP safety database, which is the largest database of safety performance in the exploration and production (E&P) industry. The annual reports provide trend analysis, benchmarking and the identification of areas and activities on which efforts should be focused to bring about the greatest improvements in performance.

The IOGP incident reporting system covers worldwide E&P operations, both onshore and offshore, and includes incidents involving both member companies and their contractor employees.

Total man-hours worked in Oil & Gas industry is increasing year on year. There is a 16% increase in total man-hours worked including employees and contractors during the year 2014. Therefore the rate of exposure to work place hazards is a greater challenge. However, introduction of life saving rules associated with behavioral aspects by IOGP and its practice by member Organizations have resulted in reducing serious accidents.

The IOGP lifesaving rules focus on modifying behaviors at workplace and created a sense of zero tolerance towards at risk behaviors. Adopting these rules found to be great effect on reducing fatal accidents rates. During the year 2014, there was about 51% reduction in fatal accident rate. It is further reported that 78% of fatal accidents would have been averted by following lifesaving rules. These rules are significantly supported by behavioral changes and timely interventions.

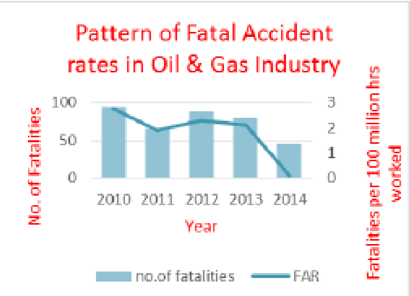

Figure 1. Pattern of fatal accident rates as per IOGP

The pattern of Unsafe acts, unsafe conditions and near-misses contributing for incidents are represented as:

Figure 2, Concept representation of unsafe act /unsafe condition, near-misses and incidents

While analyzing the lost time cases of one of the E&P company, it is observed that fall of objects from a rig floor, fall of personnel from height during rig operation, fall of personnel into cellar pits, fall of personnel due to collapse of false flooring were the causes. Relatively reporting of related near-misses, unsafe conditions and unsafe acts were low or adequate controls were not established to prevent recurrence of the incidents. However, when the Organization intensified their intervention programs and continuous education on recognizing the hazards before starting the every job, creating safe work environment have significantly increased number of near-misses and Unsafe conditions and Unsafe acts reporting.

III. Methods and Materials

Collection of near-miss data of an Upstream Oil & Gas installation, interaction with field personnel in understanding their interpretation of near-misses and safety observations, work place safety inspections, lessons learnt from various incidents were the methods adopted in this study.

A comprehensive literature survey was conducted on accident Patterns, Near-miss reporting, behavioral observations and intervention programs in Oil & Gas industry.

A survey with specific questions relevant to the study was conducted.

Why-Why process and Bow-tie analysis methods were applied as to analyses the near- misses. For each top event to result, the barriers in place, and how the barriers failed were studied. Root causes were derived from the said methods.

The number of behavioral observations at work site were collected through well designed safety observation cards. These cards were objectively designed to obtain the information on elements including personal factors, job factors, unsafe acts, unsafe conditions, Personal protective equipment and tool and equipment. Trends were plotted and identified the weak barrier in the system.

The samples for the study were collected from Cairn India, an Oil & Gas Exploration and Production company located at Barmer district of Rajasthan, India.

Cairn India is the largest independent Oil and Gas exploration and production company in India with a market capitalization of US $ 7 billion and the largest private sector producer of crude oil in India. Cairn India operates 27% of India's domestic crude oil production. The Mangala field in Barmer, Rajasthan, discovered in January 2004, is the largest onshore oil discovery in India in more than two decades. Mangala, Bhagyam and Aishwariya fields-major discoveries in Rajasthan block have gross ultimate Oil recovery of over 1 billion barrels. Cairn India was rated as the fastest-growing energy company in the world, as per the 2012 and 2013 Platts Top 250 Global Energy Company rankings.

Cairn aspires to a zero-harm environment for personnel at work. It has engaged 20000 work force in peak time of constructing well-pads, Mangala processing terminal and other associated facilities. These work force comprises unskilled, semiskilled and highly technical from various states of India and also rest of the world. The harsh climatic conditions were one of the work place Health and safety challenges. With continuous efforts, Cairn has established a strong Health, Safety and Environmental management systems engaging the workforce. As a result, it has bagged several recognitions from national and International level. It has focused to create safe work environment and recognized to bring awareness on significance of near-misses, its reporting, analyzing and corrective actions. It has encouraged the employees and contractors to report near-

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misses through periodic training programs, tool-box talks, supervisor responsibility, contractor engagement process and mass communication methods, the personnel who reported significant near-misses were recognized at highest level which motivated individual to be proactive always.

Over a period of Three years, the safety observation system has percolated to grass root level at all assets and the number of observation cards increased from 12000 during 2012-13 to 70000 during the year 2014-15. It has greatly contributed in achieving HSE excellence in a sustainable manner.

The samples of observations and near-misses collected from the data published by Cairn for the years2012-2015.

VI Result and Discussion

About 250 near-misses occurred during the year 2012-2015 at Cairn India were studied and the pattern is represented as

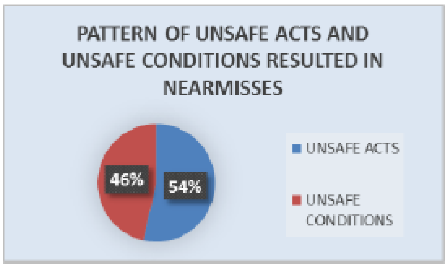

Figure 3 Pattern of Unsafe Acts and Unsafe Conditions Resulted near-misses

54% of near-misses have been contributed by unsafe acts and are directly associated with behavioral aspects.

The examples of near-misses in the study found to be:

- During routine plant round, an engineer hit against a 1/8" tubing on the platform and got tripped. He balanced himself holding the handrail. The tubing was of moisture analyzer and falling in the walkway causing a potential trip hazard.

The majority of near-misses are due to fall of objects at rig floor, fall of personnel from height, collapse of false ceiling, zero tolerance behaviors, not adhering to safety procedures.

It also attributed that proper analysis of near-misses and strengthening the barriers have reduced its further escalation. However, serious injuries have resulted when near-misses are over sighted and missed to incorporate the barriers in place.

Understanding the mechanism, reporting the near-misses itself is the challenge at work site. This is due to lack of safety awareness and motivation. Often personnel misinterpreted the at risk behaviors as near-misses.

Specific near-misses awareness campaigns, motivation and recognition methods found to be encouraging the increase in near-miss reporting trends.

It appears that the activities those commonly being executed on day to day basis and the observers made maximum number of observation on those activities, are having less number of incident or no incident.

At the same time the common activities those being executed on day to day basis but having less Safety observation, are having more number of incident.

Therefore the theory of behavioral modulation can be proved right through this data. More monitoring and interference by first line management on a particular activity can help to reduce the chance of incident greatly in that area.

Unsafe acts, unsafe conditions and Near-misses are the core components in the accident occurring patterns.

Behavioral interventions are significant in bringing awareness among work men in preventing accidents.

About 10000 Safety Observations were analyzed and the key findings are:

95% of Observations reflecting safe work practices demonstration by the workforce. These observations program made an opportunity for all level of personnel to involve in building safety culture.

The remaining 5% Observations are attributed to personnel not following the procedures, inadequate work supervision, and competency of work force, work pressure and poor safety awareness.

About 250 samples (safety observations) are considered for analysis and the trends are represented as

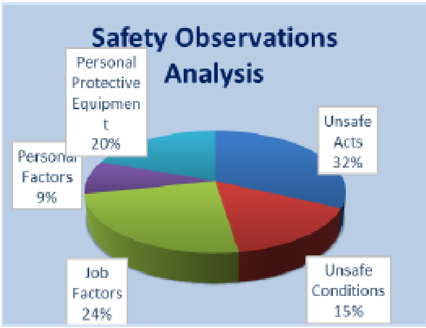

Figure 4 Safety Observation Analysis.

Unsafe acts (32%) found to be the major contributor followed by Job factors (24%) and noncompliance to personal protective equipment (20%). Unsafe acts including are procedures not followed and failure to make work place safe. The Job factors includes inadequate leadership / supervision, poor housekeeping issues. Therefore all these factors may be corrected with employee engagement process, timely interventions and positive feedbacks.

The barrier in the process found to be

- Inadequate visibility of Top Leadership on the ground
- Lack of ownership from Front line Supervisors
- Contractor performance monitoring and control
- Poor competency levels of Contractor supervisors
- Delayed response in closing unsafe conditions/acts

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Typical Safety Observations in the study found to be:

- Stopper for the Pipe rack were not in practice. This repeat observation resulted in a lost time injury involving roll over of pipes and a contractor workmen was trapped in between the pipes. It is significant that overlooking the safety observations lead to near-misses and further repetition of same incidents lead to serious accidents.
- Personnel found not using three point contact while ascending or descending the ladders or stair cases.
- Poor control on grating management i.e. either gratings are missing at platforms or not properly fixed have created a high risk incidents.
- Poor housekeeping includes, slippery floors, tools on floor, access / egress
- However, a significant improvement on housekeeping at work place was observed through safety observations reports.
- Noncompliance to use of personal protective equipment.

In another case study published in IOGP, after reviewing work-related fatalities that occurred between 2000 and 2008, Shell found that a failure to comply with a limited number of safety rules was a significant factor in the majority of cases. In response, Shell launched a programme to reinforce what employees and contractors must know and do to help prevent serious injury or fatality. Compliance is mandatory for all Shell employees and contractors while on business or Shell sites. The 12 Shell Life-Saving Rules were launched in 2009 across the company.

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The author thanks his guides and co-authors Dr Nihal Anwar Siddiqui **, Head of the Department, Health, Safety & Environment, University of Petroleum & Energy Studies, Dehradun, Uttarakhand, India and Dr D K Gupta***, Head of the Department, Petroleum Engineering and Earth Sciences, University of Petroleum & Energy Studies, Dehradun, Uttarakhand, India.

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Authors

First Author – Siva Prasad Penkey is an M.Tech., in HSE from University of Petroleum & Energy Studies, Dehradun and also M.Sc in Chemistry from Andhra University. He was awarded a Diploma in Industrial Safety from Regional Labor Institute - Chennai and Post Graduate Diploma in Environmental Sciences from Andhra University. He is also G-IOSH member in Institution of Occupational Safety and Health (IOSH) and a Specialist (SIIRSM) in International Institute of Risk & Safety Management (IIRSM). He is having 28 years of experience in the field of Health, Safety and Environment.

He is having exposure to Oil & Gas, Petroleum Refining, Petrochemicals, Engineering Procurement and Construction Industry and Nuclear fuel processing Industries within India and abroad.

Played a key Health, Safety and Environmental leadership roles in various Organizations

- Cairn India ltd
- Reliance Industries ltd
- Bhabha Atomic Research Centre (Atomic Energy of India)
- ISCO, one of the largest EPC Company in Kuwait

Siva Prasad Penkey has several papers on work place safety improvements presented during national and International Conferences. He has carried out work place research on "Participation approach improves work place Health and Safety". Presented a paper in American Industrial Hygiene Conference and Expo, May 21-26, 2005, Anheim, California, USA. He was also active member as Head, Occupational Health and Safety of ASSE Chapter Kuwait. He carried out more than 50 accident investigations. He mentored more than 20 University students for their project works.

Second Author – Dr. Nihal Anwar Siddiqui did his post-graduation in Environmental Science and Doctorate in Environmental Biology. In addition he is also having Diploma in Industrial safety & Post Graduate Diploma in Environmental Impact Assessment. The topic of his research was on Environmental Impact Assessment. Dr Siddiqui specializes in the area of Environmental Pollution, Env.Monitoring and control techniques. Dr. Siddiqui started his career as Assistant Professor in Institute of Environment & Management and because of his desire to work in the real field he joined as Environmental Engineer, Paryacon Engineers a leading consultancy in the field of Env. Pollution and control. He was part of number of EIA projects, Environmental Audit and Env. Monitoring. Dr. Siddiqui

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got chance to work with Environmental Engineering Division of Central Pulp & Paper Research Institute as Scientist. During his stay with Environmental Eng. Div., Dr. Siddiqui work on 8 major R&D projects for various agencies like Central Pollution Control Board, New Delhi, MOEF, PWC and various projects sponsored by RAC. Dr. Siddiqui did some of the pioneer work in the area of odor Monitoring and providing control technology along with Finland Scientist. Dr. Siddiqui was also associated with Health, Safety & Environment dept. of ICEM college, Muscat, Oman which is affiliated to University of Central Lancashire, UK. He has more than 104 Research papers to his credit has participated in several National and Intl conferences. Dr. Siddiqui has authored 2 books vizNatural Resources & Environmental Management & Handbook on Fire & safety. Dr. Siddiqui has guided more than 50 M.Tech and 11 PhD theses.

Appendix# 04

RESEARCH SCHOLAR'S PROFESSIONAL SUMMARY

Health, Safety & Environmental professional with 29 years of experience.

Currently engaged as **Safety Engineering Specialist** for Kuwait Oil Company. Responsible for HSE Management System element Competency, Training and Behavioural Safety implementation. Principal Subject specialist for training the employees, contractors of all levels in HSE Induction, Accident Prevention Program, Behavioural Based Safety, Job Safety Analysis, Safe handling of Chemicals, Site Verification Visits, EOD, Defensive Driving, Work site supervisor and Safe handling compressed gas cylinders.

Worked as **Deputy General Manager**, Corporate HSE of Cairn India Limited an Oil & Gas exploration company.in India. Successfully Lead HSE systems compliance and assurance Process.

Played a key HSE leadership role in Cairn India's growth story of Oil and Gas Exploration, Drilling and Production facilities including 600 km of largest underground insulated pipeline.

As General Manager, Corporate Health, Safety, and Security & Environment for an EPC company having 5000 employees in Kuwait provided HSE leadership role for Refineries, Petro Chemicals and Oil & Gas industries.

As Group HSSE Manager for Petroleum Terminal Operations of Reliance Industries Limited, India. Provided leadership in establishing workplace safety and safety culture at 10+ Bulk petroleum terminal Operations, road and rail transportation. Spearhead the implementation of HSE standards equivalent to Shell at all Reliance assets.

As HSE Manager for Refinery Tank farms, Rail Road Terminals, Fluidised Catalytic Cracking Units (FCCU) in Worlds largest Refinery of Reliance Industries, Jamnagar demonstrated a leadership and an advisory role to ensure best practices.

AS Scientific Officer (Health & Safety) associated with implementation of Health and Safety at work place of India's most prestigious nuclear projects of Bhabha Atomic Research Centre, Atomic Energy of India.

Technical papers presented:

- "Participatory approach to sustainable Occupational Health and Industrial Hygiene Improvement at Work place" during world conference organised by ACGIH held at California-2005.
- "Vehicle Tracking System-a useful tool in road safety management" during 5th International Conference of American Society of Safety Engineers.
- "Contractor Safety-a key for Business success during 7th India Drilling & Exploration Conference (IEDC) 2015
- "Disaster Management in Pipe line operation" during Chemical (Industrial) Disaster Management (CIDM): Chemical, Pharmaceutical and Hydrocarbon Industry, Goa, India
- "Gated process-A versatile tools in project HSE Management" during 7th International HSSE and Loss Prevention Professional Development Conference and Exhibition, Kuwait
- "A Journey towards Behavioural Excellence" during Safety Ex exhibition & conference in New Delhi
- "Role of Leadership in Transforming HSE culture" 3rd FICCI Conference on Safety & Safety Systems Excellence awards for manufacturing, New Delhi
- Effective Behavioural Interventions Improves HSE Culture-ASSE-Kuwait Chapters' PDC, 2015.

Awards Received :

- Received HSE Professional Recognition Award from 'American Society of Safety Engineers' Kuwait Chapter.
- "Bronze Award" for M/s ISCO for demonstrating Health, Safety & Environment Management Excellence in a private sector companies in Gulf Countries Council during the year 2008.

Personal Skills:

- Positive attitude with good decision-making skills
- Possess excellent technical knowledge and ability to handle multiple tasks.
- Ability to lead a team with result-oriented management skills
- Extensive knowledge of HSEQ Management System Elements

Profile

Education	M Tech-HSE-University of Petroleum & Energy Studies M.Sc (Chemistry)-1986-Andhra University Diploma in Industrial Safety-1992-Regional Labour Institute-Chennai. Post Graduate Diploma in Environmental Sciences-1994-Andhra University. G-IOSH, SIIRSM
Total Experience	29 Years
Industry Exposure	Oil & Gas Petroleum Refineries Bulk Storages of Hydrocarbons & Handling and Transportation Petroleum Terminal Operations and augmentation EPC Projects Power Sector Nuclear Industry
Technical Skills	Health, Safety & Environment Management Systems implementation, Safety Audits, Occupational Health Improvement Projects, Risk Assessments, Plant Commissioning & Operation and Safety Training.

Awards and Recognitions:

The Scholar received Cairn India-CEO's Safety Champion Award for establishing state of art Emergency Management Control Centre at Cairn India-2014.

Received recognition for best safety professional contribution for the American Society of Safety Professionals (ASSE)-Kuwait Chapter.

The Scholar received Bronze Award for implementing Safety Management Systems in a largest EPC company in Kuwait from American Society of Safety Engineers (ASSE-Kuwait Chapter).

Exposure to Advanced Technologies & International Institutes:

During the research period the scholar got opportunities to visit or interact with the following Research Institutes/ Laboratories/ Organisations:

The Scholar with Dr Bill Nixon, Health and Safety Laboratory (HSL), Buxton, UK.

The Health and Safety Laboratory is one of the world's leading providers of health and safety solutions to industry. Involved in many accident investigations and safety research.

The Scholar with Safety Specialists from M/s ASET, Aberdeen, Scotland, UK
M/s ASET Provides Emergency Management Competency services.

End of Thesis.