STUDY OF SAFETY MANAGEMENT SYSTEM IN GAS PROCESSING PLANTS AND REFINERIES IN INDIA

BY

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(DEPARTMENT OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT)

SUBMITTED

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

TO

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
DEHRADUN
(December 2018)

UNDER GUIDANCE OF

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DECLARATION

I declare that this thesis entitled STUDY OF SAFETY MANAGEMENT SYSTEMS IN GAS PROCESSING PLANTS AND REFINERIES IN INDIA has been prepared by me under guidance of Dr. Atul Razdan, Associate Dean (Undergraduate Business School), UPES, Dehradun. No part of this thesis has formed the basis for the any award or any degree or fellowship previously.

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I dedicate this thesis to my beloved father late Dr. B B Gupta who taught me that there is no substitute for hard work.

ACKNOWLEDGEMENTS

I share my sincere gratitude to University of Petroleum and Energy Studies, Dehradun for giving me an opportunity to carry out this research. I am highly indebted to Dr. S J Chopra, Chancellor and Dr. Deependra Kumar Jha, Vice Chancellor for their words of wisdom and motivation.

I thank Faculty Research Committee (FRC) for guiding me to do the research on the topic of my interest and providing continual support in terms of valuable suggestions for betterment of my thesis.

I would like to express the deepest appreciation to my guide Dr. Atul Razdan who continuously encouraged and guided me at every step of the research. The guidance and support provided by Dr. Joji Rao was invaluable. Without their guidance and persistent help this thesis would not have been possible. I would also like to thank my external guide, Dr. D Roy for being a constant source of inspiration and guidance throughout my research process.

My deepest gratefulness to Mr. A C Bhushan my colleagues for his extreme hard work in providing continuous support and displaying extraordinary spirit and concern for early completion of this research work. I am grateful to Dr. Anjali Midha Sharan & Mrs. Rakhi Ruhal for their continuous support for facilitating my research by helping out with a number of administrative issues.

I would also like to express my gratitude to Dr. Narendra Kumar and Dr. R S Velmurugan my colleagues from GAIL for providing meaningful insights into research.

I am also indebted to my all other colleagues who provided their valuable inputs and comments on my research work. I would also like to share credit of research work with my colleagues of Vijaipur and Vaghodia, who shared their experiences through research questionnaire and the interviews. My friends, colleagues and employees of M/s IOCL and M/s EIL generous in extending their support to this research work. I thank them too.

This acknowledgement will not be complete without mentioning deep sense of gratitude I have towards my father late Dr. B B Gupta, mother Mrs. Shakuntala Devi, Aunt Smt. Jaya Agarwal, Uncle Shri J S K Agarwal, Brother Shri S S Agarwal and sister Mrs. Satya Bala Gupta and Mrs. Satya Prabha Mittal, whose blessings helped me in completing this research work.

Most importantly, none of this could have been possible without the love and patience of my family. My immediate family has been constant source of love, concern, support and strength all the years. I would like to express my heart-felt gratitude to my wife Mrs. Sujata Garg and beloved daughters Ms. Shaurya Garg and Ms. Ananya Garg, who have always stood by me and have been source of inspiration for me in achieving new milestones.

Dehradun, …………………. **Satya Prakash Garg**

DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief it contains neither previously published nor written material by another person nor any material which has been accepted for the reward of any degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text.

Satya Prakash Garg

Date: ………………....

Date: ……………….

THESIS COMPLETION CERTIFICATE

This is to certify that the thesis, "Study of Safety Management System in Gas Processing Plants and Refineries in India", by Satya Prakash Garg in partial completion of the requirements for the award of the Degree of Doctor of Philosophy is an original work carried out by him under our joint supervision and guidance.

It is certified that the work has not been submitted anywhere else for the award of any other diploma or degree of this or any other University.

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EXECUTIVE SUMMARY

Oil and Gas industries are the engines of world economy, which mainly drive the growth and industrialization worldwide. There are approximately more than 1200 Oil and Gas Companies operating in the World, mainly involved in exploration, production, refining and transportation activities. With globalization and rapid industrialization, there is significant jump in Oil & Gas production in India post-Independence, which is associated with non-speculative risks of fires, explosions, toxicity, environmental pollution etc. Such emergencies/disasters pose a great threat to human life, flora & fauna. Indian Refining industry has done exceedingly well in establishing itself as a major player globally. India is emerging as a Refinery hub and Refining capacity exceeds the demand in India.

With increasing demand and production of Natural gas/Petroleum products, Gas Processing and Refinery units are set up to meet the desired requirement of country. These Gas Processing Units and Refineries are handling various hydrocarbons like Natural Gas, LPG, MS sprit etc., which are hazardous in nature and pose increased risk to the human lives, property and environment. Government of India has established comprehensive legal framework for Installation, Operation & Maintenance of such industries, to take care of associated hazards and their consequences in case of any release.

Oil & Gas Industries have established their Safety Management System with an objective of risk reduction. In spite of multi-layer protection system approach, accidents are regularly happening. Also, it is evident that amongst developing countries in the world India stands with highest number of Major Industrial Accidents in Oil & Gas Industries during the period 1917-2011.

Oil Industry Safety Directorate (OISD) a technical wing of Ministry of Petroleum and Natural Gas, Government of India, involved in analysis of major incidents, as reported by Indian Oil & Gas Industries. They got 879 reported incidents during the period during year 2004-2017, out of which 186 incidents belong to Gas Processing Plants and Refineries of India,. This number is very large and cause of worry to the industry. For the purpose of our study we have considered figures of fatal/reportable accidents (which mean loss of lives or severe injuries) and fire incidents involving loss of property only, and compared this data with Pipelines and Marketing Segments (OISD, 2010). These fire incidents and fatal accidents also resulted into loss of Rs. 116 Crores (Approximate) during 2006-07 to 2011-12 in Indian Refineries and Gas Processing Plants.

Generally, all the Gas Processing Plants and Refineries do have elaborate "Safety Management System". But, since there are large nos. of major accidents causing loss of lives and property, it is important to study 'Safety Management System' in Gas Processing Plants and Refineries of India, to strengthen and make it more effective in loss control. It is needed to look into various contributory factors like Organizational, Environmental, Individual, Safety Culture, Incident Reporting and Analysis etc, also which are impacting the effectiveness of "Safety Management System" to address this serious problem.

Various literatures and publications on Accident Causations and Safety Management System were studied in detail. Based on study an effort has been made to identify main variables/factors applicable to respective industry concerned and to identify main theme addressed in those papers. A summary of all the Literature Review has been presented subsequently. That illustrates context of theme and variables and summarizes all the studied literature, tabulates common themes under one column and thereby draws inferences. Based on above literature review, the gaps in literature can be summarized as:

1) No existing literature for Safety Management System in Gas Processing Plants and Refineries in India.

2) Studies have been carried out on Safety Management System in India but these are limited to field of Construction, Disaster, Carbon Di-Sulphide plant, Mining, Road Safety etc.

3) Studies have also been carried out worldwide on Safety Management System in the field of Maritime, Steel, Oil & Gas, Petrochemical Processing Plant, Airlines, Transport Section, Hospital etc. but no comprehensive study has been done taking into account factors of Safety Management System in Gas Processing Plants and Refineries in India, as identified.

Relationship has been established between literature gaps and theoretical premise to define the Problem Statement for Research Work. The Problem Statement emerged as

"Large number of major accidents took place in Gas Processing Plants and Refineries in India, which resulted into severe injuries, loss of human lives and huge financial losses, in spite of having "Safety Management System" in place

As the literature review shows, there has been no earlier study of Safety Management System in Gas Processing Plants and Refineries. There is a need to understand existing Safety Management System and develop a model for Safety Management System in Gas Processing Plants and Refineries in India."

Accordingly, specific objectives have been written down for my research work alongwith research questions 1) How National Gas Processing Plants and Refineries plan and execute their Safety Management System and related processes, to ensure safety in Operation and Maintenance? & 2) What are the factors in developing good Safety Management System for Gas Processing Plants and Refineries in India?

The research methodology used for Research is the "qualitative research". Gas Processing Plants and Refineries have been chosen for this study accordingly. A **multi case holistic design** (Type 3; Yin 2003) of case study research design has been selected for this research work. The proposed methodology followed shall be a 'Case Study Method' having 'Multiple holistic case design' considering two cases of Gas Processing Plants and Refineries each. Each one of Gas Processing Plant & Refinery having nearly 'NIL' (good) accident record (with respect to Reportable Accidents, Fatal Accidents, Fires and Explosions) and the other Gas Processing Plant and Refinery each having 'Poor' accident record (with respect to Reportable Accidents, Fatal Accidents, Fires and Explosions) in last five years (2009-2015), have been selected to study existing "Safety Management System".

A Maharatna gas utility company has been chosen for the study on safety management system and processes of Gas Processing Plants since it is having larger market share in natural gas processing and it is a No. 1 gas utility company in India. The Company, a Maharatna Public Sector Undertaking, is having 5 Gas Processing Plants, 2 Petrochemical Processing Plant, more than 11000 KM Natural Gas Pipeline networks and 2050 KM LPG pipeline networks.

Another India's flagship Maharatna National Oil Company with business interests straddling the entire hydrocarbon value chain – from refining, pipeline transportation and marketing of petroleum products to Research & Development, Exploration & Production, marketing of natural gas and petrochemicals, has been chosen for the study of safety management system and processes of Refineries.

The data was collected from the Operation, Maintenance and Fire Safety Managers of Oil & Gas Companies using **case study protocol.** The maintenance, operation and fire safety managers working in these plants were interviewed based on their availability, either at site location or at head office. Finally, interviews were conducted from these operation, maintenance and fire safety officials covering both the case studies i.e. Case Study 1 & Case Study 2. Also, a detailed case study protocol was developed before data collection and semi structured interviews were conducted with Safety Experts along with HR Executives and Licensors for Objective 2

Data Analysis was carried out utilizing Textual Analysis and Cross Case Synthesis methodology. Textual analysis was done with the help of Atlas TI software and network diagrams were formulated with the necessary quotation and frequency analysis using open coding, focused/selective coding and identifying patterns of relationship among conceptual categories.

Accordingly, a theoretical model has been developed and validated with the empirical results utilizing, cross-case analysis. This model of a “Safety Management System for Gas Processing Plants and Refineries in India” is based on various factors, as identified during study of existing safety management system. The new model includes Organizational, Environmental, Individual and Regulatory Factors which need to be supplemented with Organizational Safety Culture (Leadership and Commitment at all Levels, Adaptation of Best Safety Practices, Behaviour Based Safety, Leveraging IT to Safety, Safety Benchmarking, Role of Safety Professionals etc.) to achieve total loss control. The subject model will effectively fill-in the existing gap and shall provide tools to manage Safety Management System and processes more efficiently, ultimately leading to good safety culture and good safety records in the organizations.

The results of this research work provide an insight into the processes of Safety Management System in Gas Processing Plants & Refineries.

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LIST OF ABBREVIATIONS USED

BBS	: Behaviour Based Safety
BBU	: Bitumen Blowing Unit
CEO	: Chief Executive Officer
CISF	: Central Industrial Security Force
DHDS	: Diesel Hydro Desulphurisation Unit
EHSM	: Environment, Health & Safety Management
FCCU	: Fluidised Catalytic Cracking Unit
GDP	: Gross Domestic Product
GPP	: Gas Processing Plant
GDN	: Guideline
HSE	: Health, Safety & Environment
HAZOP	: Hazard and Operability Study
ILO	: International Labour Organization
ISO	: International Organization for Standardization
IMS	: Integrated Management System
ISRS	: International Safety Rating System
LPG	: Liquefied Petroleum Gas
MMTPA	: Million Metric Tons per Annum
MOPNG	: Ministry of Petroleum and Natural Gas, Government of India
MSDS	: Material Safety Data Sheet
MSIHC	: Manufacturer Storage and Import of Hazardous Chemicals
OISD	: Oil Industry Safety Directorate, MOPNG
OHS	: Occupational Health & Safety
OHSAS	: Occupational Health and Safety Assessment Series
OIC	: Officer In-Charge
PPE	: Personal Protective Equipment
PDCA	: Plan, Do, Check and Act
PNGRB	: Petroleum and Natural Gas Regulatory Board
QRA	: Quantitative Risk Analysis
QMS	: Quality Management System
SPADS	: Signal Passed at Danger
SOP	: Standard Operating Procedure
SMS	: Safety Management System
VBU	: Vis-breaker Unit
UNEP	: United Nation Environment Program

CHAPTER 1.0: INTRODUCTION

1.1 BACKGROUND

Globally, growth and industrialization have been driven by Oil and Gas Industries, playing major role in controlling world economy. Involved in exploration, production, refining and movement of Oil and Gas through various means like Pipelines, Road/Rail Tankers etc, there would be more than 1200 Oil and Gas Organizations all over the world. After rapid globalization and increased industrialization, Oil and Gas recovery and productions have gone up quite significantly in India after country's independence. Increased production always gets associated with increased risk of environment related pollution, incidents of fires and explosions etc. threatening human lives and existence of flora and fauna.

Refining industry of India has grown well, over last couple of years. It is emerging as major global player in refining. In India, today refining capacity is much more than demand. Our refining capacity has increased tremendously over last two decades from 62 Million Metric Tons per Annum (MMTPA) in 1998, we have grown to 234 MMTPA capacities. We have total 23 refineries out of which 18 are under public sector. Two new refineries came up in 2011-12 having capacity of 6 MMTPA and 15 MMPTA respectively at Bina in Madhya Pradesh and Bathinda in Punjab. Both refineries got established under joint venture. Year 2017 saw another large refinery IOCL coming up at Paradip, Orissa having 15 MMTPA capacity. We have 11 Nos. of Gas Processing Plants in India, out of which 6 nos. are operated by GAIL (India) Limited.

Due to environment friendly properties, economics and efficiency considerations, Natural Gas has gained the popularity as being most preferred fuel. As a result, Natural Gas demand has grown many folds during last two decades, worldwide. In our country too, Natural Gas has gained popularity and its demand has increased, especially during last 10-15 years.

With increased requirement, production and utility of Natural Gas and Petroleum Products in the country, new facilities of Refineries and Gas Processing are coming up. These Gas Processing Units and Refineries handle various hazardous hydrocarbons like Natural Gas, LPG, Motor Spirit, Diesel etc. which are inflammable and pose severe risk to living beings, property and environment etc. Indian Government has put in place various statutes and legal provisions for managing Designing, Construction, Operation and Maintenance of such installations, so as to appropriately tackle various hazards and minimize consequences in case of any accidental release, fires or explosion etc.

Various organizations in Oil & Gas Sector have formulated their own Safety Management System to manage associated risks. But, even after having many layers of protection system as per Safety Management System, accidents keep happening, resulting in to loss of lives and property. Amongst developing countries in the world, it has been found that India had maximum major Industrial Accidents in Oil & Gas Industries during the period 1917-2011 (Efthimia K. Mihailidou, Konstantinos D. Antoniadis & Marc J. Assael November 2012).

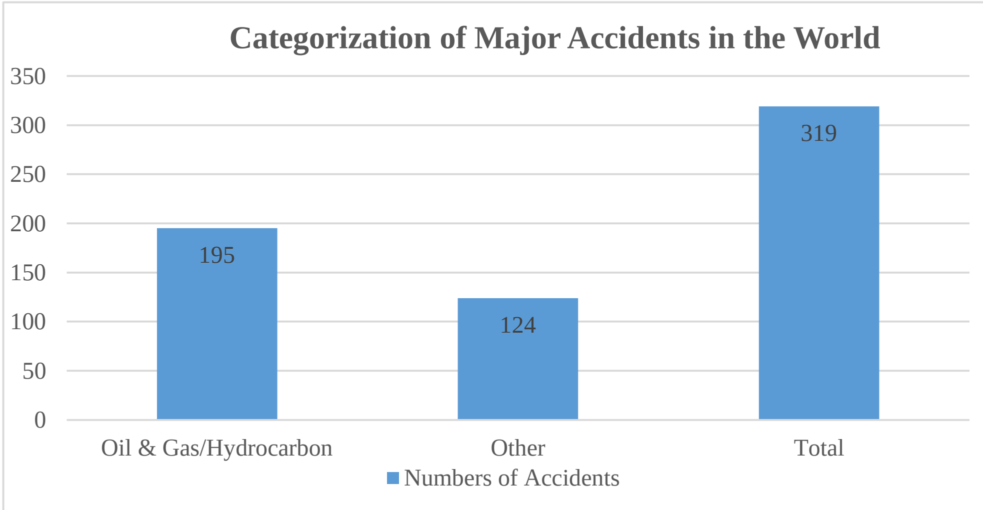


Figure 1.1.1

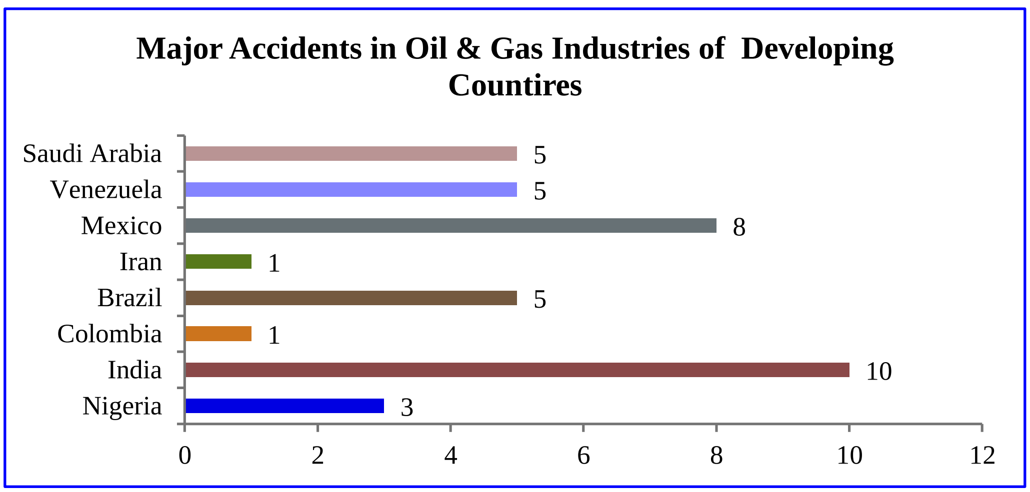


Figure 1.1.2

Technical wing of Ministry of Petroleum and Natural Gas, called as Oil Industry Safety Directorate (OISD) carried out some study on major accidents in Oil and Gas Industries in India for year 2004-2017, with following criterion in mind:-

"The accident having-

- Fatality or permanent loss of body parts or permanent disability
- Loss of property more than Rs. 5 Lacs
- Shutdown of plant/facility
- Blow out/Explosion
- Loss of more than 500 man hours
- Fire of more than 15 minutes duration
- Failure of rig critical equipment like draw works, casing line etc."

The outcome of such study was quite eye opener. It was fond that out of total reported incidents of 879 numbers during that period, 186 nos. alone happened in Gas Processing Plants and Refineries in India. This number was quite alarming. No. of fatalities were found to be highest in GPUs and Refineries, as compared to other business segments of Pipelines, Marketing Installations and Exploration & Production.

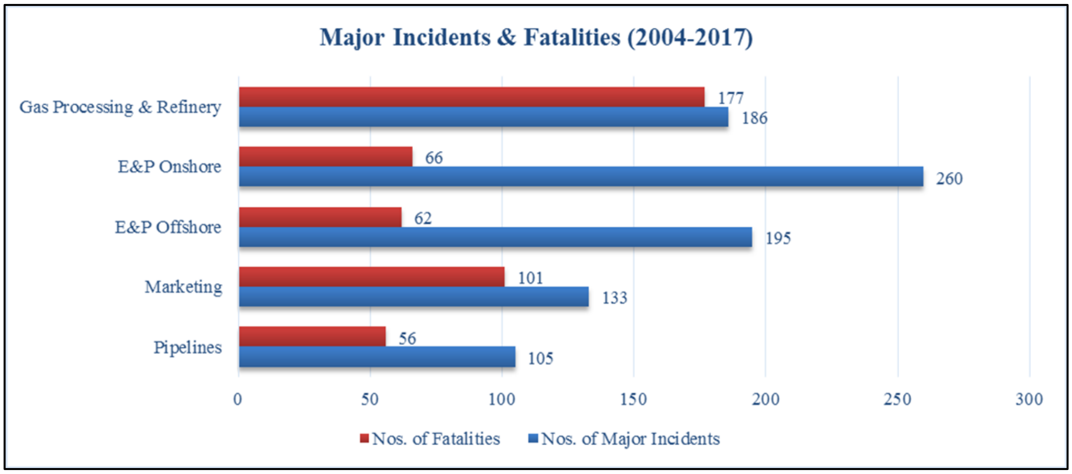


Figure 1.1.3

These incidents also resulted into huge property losses, draining in crores of rupees. Following Table No. 1.1 depict the quantum of property losses during year 2006-2011 (Standing Committee on Petroleum and Natural Gas, 2011-2012):

Table 1.1.1

	Financial losses (Rs in Crores)						
Year → Group	06-07	07-08	08-09	09-10	10-11	11-12	Total
Refineries and GP	20.48	36.04	0.00	46.90	1.89	10.70	116.0
Exploration and Production (Onshore)	0.15	0.10	0.14	0.05	0.00	1.31	1.75
Exploration and Production (Onshore)	0.00	0.00	0.30	0.00	0.50	1.00	1.80
Marketing Installations	0.00	0.25	3.72	247.20	31.60	0.00	282.7
Pipelines Installations	0.28	0.15	0.27	49.24	0.16	1.06	51.16

Major Fires and Accidents also happened at Chennai Petroleum Corporation Limited (CPCL)-Manali, ESSAR Jamnagar Refinery and HMEL-Bhatinda Refinery and Panipat Refinery in recent years. This means that accidents are regularly taking place even today.

Generally, all the Gas Processing Plants and Refineries in India do have quite elaborate "Safety Management System". But, even than these accidents are happening in large numbers, causing damage to properties and loss of lives. As such, to strengthen the Safety Management Systems and to make those more effective, it is need of the hour to study "Safety Management System" and various contributory factors, which are impacting effectiveness, to address this issue of serious concern.

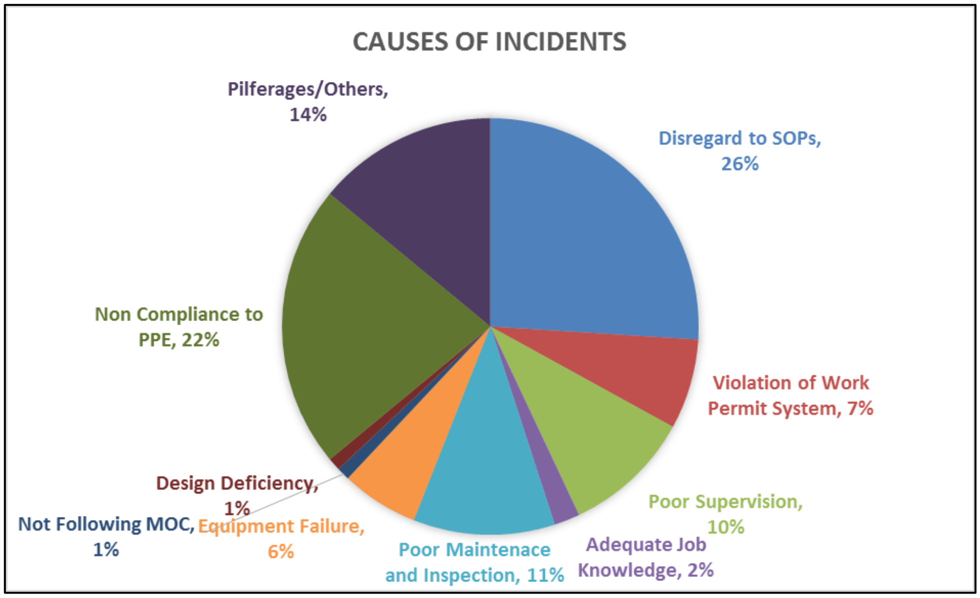


Figure 1.1.4

It can be seen from above Figure that Organization Factors like Design Deficiency, Equipment Failure, Poor Maintenance and Inspection etc., Environmental Factors like Violation of Work Permit System, Disregard to SOPs etc. and Individual Factors like Non Compliance of PPEs, Adequate Job Knowledge, Poor Supervision etc. were found as attributes to major incidents in Gas Processing Plants and Refineries.

1.2 BUSINESS PROBLEM

Many injuries, fatalities and large economic losses have happened because of multiple accidents which have taken place in various Gas Processing Plants and Refineries in India. Since these installations have established Safety Management System, the issue attains serious concern.

- As such to strengthen the Safety Management System and make those more effective, it is need of the hour to study "Safety Management System" and various factors which contribute in increasing effectiveness of the system.

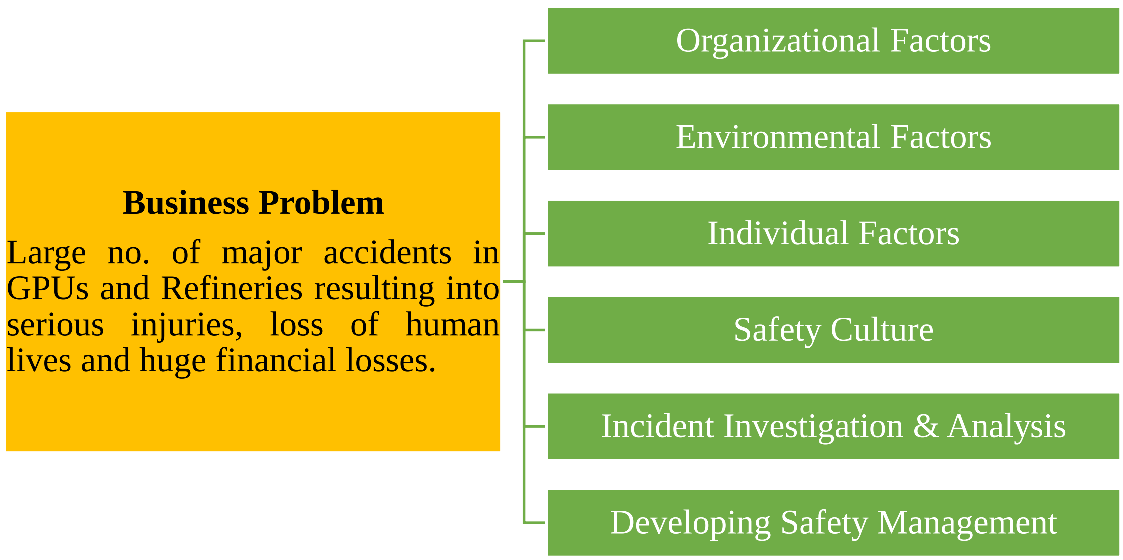


Figure 1.2.1

CHAPTER 2.0: LITERATURE REVIEW

2.1 CONCEPTUAL FRAMEWORK

To reduce and to achieve zero major accident rate, Safety Management System has to be effective and impactful. With renewed focus on effective management controls, Safety Management System handle various risks associated with Operation, Maintenance and Construction activities. Employee empowerment in accident prevention activities and in the monitoring and overseeing safe execution of work practices brings continual improvement in performance of GPUs and Refineries.

As per Oil Industry Safety Directorate, Ministry of Petroleum & Natural Gas, Government of India (OISD, 2001), Safety Management System of various Oil and Gas Industries should consist of following:-

"Nineteen Elements:-

1. Safety Organisation
2. Employees Participation
3. Process Safety Information
4. Process Hazard Analysis
5. Operating Procedures
6. Training
7. Contractors
8. Pre-Start up Safety Review
9. Mechanical Integrity
10. Work Permit

11. Management of Change
12. Incident Investigation and Analysis
13. Emergency Planning and Response
14. Compliance Audit
15. Occupational Health
16. Off-the job Safety
17. Customers and Products
18. Road Transportation
19. Trade Secrets”

Major incidents data in Refineries and GPPs of India during year (2004-2015) shows 171 nos. of major incidents, out of which 119 were accidents involving human deaths/Others and 52 were fire incidents. (OISD, 2016). Data for major incidents (Fires & Accidents) in Refineries and Gas Processing Plants in India during year 2009-2011, also illustrate similar trend (30 incidents) (Standing Committee on Petroleum and Natural Gas, 2011-12). It can be seen through the study that Procedural Lapses – Non Adherence, System Design and Deficiency, Failure of Equipment, Human Error etc. have contributed as key causes towards major incidents in Gas Processing Plants and Refineries in India, during the period of 2004 to 2015.

These incidents had major impact on reputation of organizations and on their capabilities of safely operating their installations. Such incidents also incurred huge direct and indirect financial losses during outages of plants and machineries. It is important to mention that no major accident and incident occurs without many warnings, which get ignored or remain un-addressed. There is need to have detailed study of Safety Management System in Gas Processing Plants and Refineries of India.

2.2 LITERATURE REVIEW

Leading technical journals and articles on "Safety Management System" and related topics have been referred through Internet, Standards, Guidelines and other literature. The objective to review the literature was to understand the studies and research already carried out on the "Safety Management System", to study safety procedures/safety policies followed and to analyse their effectiveness in Gas Processing Plants (GPPs) and Refineries in India. And also, to study the impact of such system on the prevention of Accidents. Key areas of review were:

- ✓ Safety Management System
- ✓ Loss Causation Models
- ✓ Accident Reporting System
- ✓ Near Miss Incidents Management System
- ✓ Role of Human factor in the accidents
- ✓ Analysis of Accidents/Incidents in Oil & Gas Industry.

There have been so many other notable cases of catastrophes where management could not identify and could not take mitigation measures in advance before a disaster struck. Some of the significant examples where failure possibilities were known but could not be addressed in-time includes:-

- Space-Shuttle Challenger explosion in the year 1986: During 1982 mission, engineers could identify and report defective O-ring seals and could establish O-ring deterioration which was increasing with decrease in ambient liftoff temperature. Before disaster struck, previous night warning of the possibility of serious failure of lower lifting off temp. of below 53 °F (Vaughan, 1996) remained unnoticed.

- The 1997 Hindustan refinery explosion in India: During refinery explosion not only 10000 MT of petroleum based various fractions got released to the atmosphere but also lead to deaths of 68 people. In this case leakage and corrosion were already noticed in transfer lines and were reported in writing, but got ignored leading to explosion (Khan and Abbasi, 1999).

- Train Crash Incident at Paddington (1999): At the incident location eight near-miss incidents had taken place between 1993-1999 and many "signals passed at danger", were reported at the place i.e "Signal 109", where ultimately train collided leading to explosion. At the time of the collision, the identified signal was one which had large number of SPADS cases. 31 people lost their lives (Cullen, 2001).

- Reactor temperature excursion leading to fire and explosion at Morton (1998): During the explosion 9 persons suffered injuries and two had serious injuries. Chemical Safety Board investigated the incident and mentioned that "Management did not investigate evidences in numerous completed batch sheets and temperature charts of high temperature excursion beyond the normal operating range". Once the process was scaled up, disproportionate number of excursions took place (Chemical Safety Board, 2000).

All the above examples very clearly indicate that near miss incidents data was not properly utilized in identifying and addressing deficiencies in the system, leading to disasters. As such, a system to capture failure scenarios or early warning, plays major role in preventing disaster. The underlying causes of an accident could be as under:-

- System or Design Deficiency
- Failure of Equipment or Plant Facilities
- Human Error – Behaviour Aspect
- Unsafe Act and Condition
- Procedural Lapses
- Inadequate Supervision
- Lack of Safety Awareness
- Training & Competency
- Non Use of Personal Protection Equipment
- Non Adherence to Standard Operating Procedures

Traditional thinking considers 'Safety' activities as 'reactive' instead of being 'pro-active'. Most of the industries used to learn lesson from incidents, after suffering losses. Historical data clearly indicates that there were enough close calls, near-misses or narrow escapes before any serious accident occurred leading to losses.

Safety Management System is aimed at providing good safety and health to workers, while at work. While plans are drawn for preventive activities, it becomes important to understand the reason behind incidents and undesirable events. In olden days, it was believed that accident happen as per God's wish and there is hardly anything one can do to avoid them. In early 20th Century, people started believing that bad physical conditions contribute to accidents.

Models of accident proneness indicate that few persons could be more susceptible to accidents than many others. During 1919 after statistical examination in ammunition factory, very first model was developed. This model was pre-dominantly accepted and lead to other research work and thought process in safety management for next 50 years. As a consequence to such thought process, workers/employees earned entire blame of accidents rather than any faulty work procedures or management processes.

Many theories of Safety Management were developed by US Army Safety Centre. Such theories also provided many accident causation models which could be utilized for writing safety programs. Safety Managers were considered to play pivotal role in driving safety programs in the factories, manufacturing shops and other organizations. Safety Manager plays advisory role in capturing operational errors and indicating to the management, for prevention and elimination of shortcomings.

To help and assist accident investigation process and the personnel involved, accident causation models were designed and developed. It was important to know and understand reasons, types of failures/ errors behind accidents. Such proactive steps could help in prevention of accidents.

H.W. Heinrich came up with Industrial accident causation theory in 1931, one of the first such theories. This is commonly known as “Domino Theory”. Heinrich analyzed 75,000 accidents which happened in the industries. He found that “unsafe acts” were reasons for 88% accidents and “unsafe conditions” for 10% accidents. He also found that behind a lost time injury there were 329 cases of similar unsafe acts or conditions. Later, he also found out that there were five factors which could be attributed to various accidents, as per Domino’s model of accident causation. These five factors were Social, Environmental, Ancestral, Individual’s fault, Unsafe act or Unsafe condition. He described all factors in detail and suggested to either eliminate or reduce their presence, to achieve good levels of Safety Management System in the organizations.

Heinrich further suggested to adopt three corrections in the system, based on three Es, so as to minimize or to avoid accidents:-

- **Engineering:** Through product design or change of process one should control/mitigate hazards.
- **Education:** Educate workers on various aspects of “Safety”. Advise Management to draw their attention on “Safety”, as it is rewarding and worth investing – in.
- **Enforcement:** It is necessary that all rules, regulations and SOPs (Standard Operating Procedures) are strictly followed by employees/ workers and the management.

Frank E. Bird, an Officer of North America working with an Insurance Company studied 1.7 million cases of accidents related to 297 organizations and 300 million working hours. He further modified Heinrich study and suggested that behind one serious or fatal accident case there would be 600 cases of apparent injury or damage cases.

Because of many disasters, especially in European countries, need of developing “Safety Management System” grew. After Flixborough incident in 1974 and Seveso incident in 1976, thinking for “Structured Safety Management System” started gaining momentum. Similarly Bhopal disaster of 1984 and Pipe Alpha Accident of 1986 further indicated towards strong need of bringing- in a good Safety Management System in organizations.

This was the time when many accident causation theories came up like “Swiss Cheese Model” given by “James Reason” in the year 1990, “Energy Damage Model”, “Epidemiological Model” etc.

In 2006 Eurocontrol Experimental Section further studied Swiss Cheese Model of Accidents and elaborated on James Reason Model of Safety Management. While presenting Accident Causation Model, James Reason brought a new concept of "Organizational Error".

During 2003, Prof. Patrick Hudson studied the history of 'Safety Management System'. During year 2000 Auto Kuuusisto wrote a paper on main functions of Safety Management System in an organization and various accident causation models. He related accident and incidents with management decisions and organizational processes. He prescribed to periodic evaluation of such management system through process of auditing. The whole purpose of Safety Auditing was to assess the effectiveness of organizational processes, so as to avoid happening of accident and incident repeatedly.

During same year 2000 N. McDonald, S. Corrigan, C. Daly and S. Cromie carried out their research and developed seven elements model for Safety Management System, called self-Regulatory Model. They described the process of safety management with focus on organizational and human factors. They described following seven elements:-

"Safety Policy, Safety Standards, Planning and Organization of Work, Normal Operating Practices, Monitoring, Feedback and Changes". They developed a guide for practice and a tool which could effectively evaluate main contents of Safety Management System in an organization.

During 2003, another group of scientists Kathryn Mearns, Sean Whitaker, Rhonaflin, Rachael Gordon and Paul O'Connor wrote a paper considering role of 'human factor' in safety Management. The outcome of their research was incorporation of human factor in well established accident investigation procedure, for better accident analysis. They also emphasized on having good accident reporting system.

Another group of leading scientists of those times Pekka Tervonen, Harri Haapasalo and Mearit Niemala studied Safety Management System of Steel Industries during 2009. In their paper they examined various aspects of Safety and Risk Management in Steel Industries including leadership and safety culture.

During 2011, two scientists Dr. R. Karuppasamy and C. Arul Venkadesh wrote a paper describing about their thoughts on Safety Management System and implementation methodology. They described ”Elements of Safety Management System including SMS Management Plan, Promotion of Safety Management, Document and Data information Management, Hazard Identification and Management of Risks, Reporting of hazards and events, Investigation and Analysis of Incident, Programs for Safety Assurance, Safety Management Trainings, Management of Change, Emergency readiness and response planning, Measurement of performance and continuous improvement”.

In 2012 Dr. R Karruppasamy and C. Arul Venkadesh further mentioned in their paper that Planning, organizing, communicating and providing direction are important part of safety management function, like other management functions. As per them, there were six elements of Safety Culture Framework having Commitment, Behavior, Awareness, Adaptability, Information and Justness.

During 2007 A M Makin and C. Windr worked on a new theoretical model to further enhance the utility of “Occupational Health and Safety Management System”. As per them systematic approach to “safety” calls for Safe System, Safe Place and Safe Person.

Later, based on PDCA Cycle, a generic “Safety Management System” was developed. If we apply PDCA Cycle to OHS then ‘Plan’ includes writing of

OHS Policy, resource allocation, provisioning of skills and organization of system, hazards and risk assessment. Real time implementation and administration of OHS Plan falls under "Do". Measurement of active and reactive performance falls under "Check" step and examination of the system in the background of continual improvement and preparing of the system for next cycle fall under final step "Act", completing the cycle.

Figure 2.2.1 – PDCA Cycle

"The Occupational Health and Safety Management System (BS 8800)" and "Dutch Safety Checklist for Contractors (SCC) standard" were the basis for application of first known Safety Management System. "ILO (International Labour Organization)" published their first guideline on "Occupational Health and Safety Systems" during the year 2001. In India, Oil Industry Safety Directorate, Ministry of Petroleum and Natural gas came up with first "OISD Standard 206" on Safety Management System during 2001. "Safety Management System" is also correlated with other "Management Systems" like Integrity Management System, Quality Management System and Risk Management

System etc. which are inter- related and having focus on minimization of risks to the organization.

Today, it is important to understand that in Indian Gas Processing Plants and Refineries, whether “Safety Management System” is impacting the accident statistics, in the same proportion, as claimed under various theories. If not, why? What are the gaps, what are the lacunas in “Safety Management System” in identification of probable failures or warnings? What are the issues and challenges associated with “Safety Management System” in Gas Processing Plants and Refineries in India?

While reviewing the large number of literature/studies available on the subject matter, an effort has been made to identify main variables/factors applicable to respective industry concerned and to identify main theme addressed in those papers. A summary of all the Literature Review has been presented in table 2.2.1.The table 2.2.1 illustrates the list of literature/studies referred in context of theme and variables.

Table 2.2.1: Literature Review Summary

SN	Context	Year	Study/ Author	Constructs Identified	Context Country/ Industry	Key Theme/Messages
1.	Theories of Safety Management	1979	Safety Management Concept Series	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2)	United State Army	Role of Safety Manager in designing Safety Management/ Programme to eliminate management rooted causes of Human/Operator Error.
2.	Achieving a safe culture: theory and practice	1999	James Reason	Safety Culture in Organization (F4) Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)	UK	The need for an organization to develop safety culture, which consists of number of interacting elements or ways of doing, thinking and managing those factors which enhance resistance to operational dangers.
3.	Near Miss System Analysis: Phase I	2000	James, UlkuOktem, Paul R & Howard	Near Miss Management (F5)	Five Fortune 500 companies	By addressing near misses effectively, large and expansive accidents may be avoided.

4.	Safety Management System – Audit tool and reliability of auditing	2000	Autro Kuuusisto	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)	-	The success of "Safety Management System" of Organization can be measured through a tool, Safety Auditing.
5.	Safety management systems and safety culture in aircraft maintenance organizations	2000	N. McDonald, S. Corrigan, C. Daly, S. Cromie	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)	-	Integrating important features of safety management system, a model was developed to serve as guiding tool for management to study and analyze main features of Safety Management System of the organizations.
6.	Near-Miss Management Systems in the Chemical Process Industry	2001	James R, Ulku Oktem, PaulR & Howard	Incident Accident Investigation & Analysis (F5)	Chemical Industry	Near miss reporting and investigation model provides significant value to organization's EHS practices.
7.	Developing	2002	Nick Horst	Human/ Individual	Europe	The development of PRIMA and

	assessment tools for Safety Management System and Safety Culture			Factors influencing Safety (F1) Organizational Factors influencing Safety (F2)		STATAS tools for assessment of Safety Management System.
8.	Motivation for Incident Reporting	2003	--	Incident Accident Investigation & Analysis (F5)	USA Aviation Sector	Development of Incident Reporting System helps to identify potential failures.
9.	Factoring the human into Safety	2003	Kathryn Mearns, Sean Whitaker, Rhona Flin, Rachael Gordon and Paul O'Connor	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)	Offshore Oil Industry	To improve accident analysis and to learn from previous incidents, taking account of Human Factor.
10.	Safety Management and Safety Culture The Long, Hard and Winding Road	2003	Prof. Patrick Hudson	Safety Culture in Organization (F4)	-	Safety Management System and associated safety cases can make significant difference.
11.	Developing internal human factors	2004	Phil Joyner & Ronny Lardner	Human/ Individual Factors influencing	Scotland Petro-chemical	Knowledge on Human factors to be assimilated into safety

	expertise on a high-hazard site			Safety (F1)		management processes and awareness developed amongst the wider workforce
12.	Accident versus near miss causation: a critical review of the literature, an empirical test in the UK railway domain, and their implications for other sectors	2004	Linda Wright & Tjerk van der Schaaf	Incident Accident Investigation & Analysis (F5)	UK Railways	To improve the process of making decisions about investment in safety enhancements, common cause analysis of accidents and failures should be done.
13.	"Near-miss" Reporting System Development and Implications for Human Subjects Protection	2005	Harvey J. Murff, Daniel W. Byrne, Paul A. Harris, Daniel J. France, Christa Hedstrom & Robert S. Dittus	Organizational Factors influencing Safety (F2) Incident Accident Investigation & Analysis (F5)	USA Clinical Research	All system failures anticipated during Research Work need to be captured for ensuring safety of the Researchers.
14.	Revisiting the "Swiss Cheese Model" of Accidents	2006	Eurocontrol Experimental Section, France	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental	Air Navigation, France	There is a need to explore incident/accident model further or to develop comprehensive theory as to "how the multitude of functions and entities in a complex socio-technical system interact and depend on each other".

				Factors influencing Safety (F3)		
15.	An Innovative Approach to "Near Miss" Capture for Improvement of Patient Safety	2007	Erika Macphee & Heather Sherrad	Incident Accident Investigation & Analysis (F5)	Canadian Hospital	Statistics obtained from near miss analysis helps to identify and address various aspects to improve safety management of patient.
16.	Seven hundred and fifty-nine (759) chances to learn: a 3-years pilot project to analyze transfusion-related near-miss events in the Republic of Ireland	2007	D Lundy, S Laspina, H Kaplan, B Rabin Fastman & E Lawlor	Incident Accident Investigation & Analysis (F5) Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2)	Ireland Hospitals	Near miss reporting should be included in incident/accident reporting system as part of proactive approach.
17.	Towards the integration of human factors root causes.	2007	Richard Scaife, Mergs & Chiara	Incident Accident Investigation & Analysis (F5) Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing	Petro-chemical	To prevent psychological adverse health cases at workplace, inclusive approach to incident investigation and analysis should be followed.

				Safety (F2)		
18.	Near-Misses and Accidents in Proactive Safety Work	2008	Published by Maritime Safety Inspectorate	Incident Accident Investigation & Analysis (F5) Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)	Swedish Maritime activities	Precursors, near misses and accident are co-related. Near-miss analysis and statistics are vital elements to develop future plans in maritime safety.
19.	Wireless Information and Safety System for Underground Mines	2008	L K Bandyopadhyay, S K Chaulya, P K Mishra & A Choure	Organizational Factors influencing Safety (F2)	Underground Mines, India	Installation of wireless information and safety system is a vital need for mining industry.
20.	Analysis of Major Incidents in Oil & Gas Industry	2009	Oil Industry Safety Directorate	Incident Accident Investigation & Analysis (F5) Human/ Individual Factors influencing Safety (F1)	Oil & Gas, India	Incident analysis is a key tool of the modern Safety Management System.

				Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)		
21.	Evaluation of Safety Management and Systems	2009	Pekka Tervonen, Harri Haapasalo and Maarit Niemela	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)	Steel Production	Safety Management System is highest priority in the organization. Its real contribution to business lies in providing a framework that helps in developing integrated business management.
22.	Theory of Accident Causation	2009	Work Zone Safety and Efficiency Transportation Center	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)	--	Understanding the causation model and prevention of accidents to develop Safety Programs

23.	Organizing HSE Management in construction of Industrial Projects	2010	Mr. S Chockalingam, Dr. T Sornakkumar	Organizational Factors influencing Safety (F2)	Construction of Industrial Project, India	"Safety performance" should be considered as one evaluation factor in the tendering process. It is an important parameter to evaluate during contract awarding stage. There is need to formulate HSE Management System Model in construction companies to improve safety performance.
24.	Best practices in near-miss reporting	2011	Published by Department of Shipping and Marine Technology	Incident Accident Investigation & Analysis (F5)	Swedish & Finnish Shipping	Effective near-miss reporting system helps in creating good safety culture.
25.	Safety and/or hazard near miss reporting in an inter energy company.	2011	P Clancy, M C Leva, V Hrymark, Michael Shrelock	Incident Accident Investigation & Analysis (F5) Human/ Individual Factors influencing Safety (F1)	Energy	Role of Safety Advisor at site is very important factor in promoting safety culture.
26.	Safety Management Measures in India for Major Threats and Hazards	2011	Dr R Kauppasamy & Sh. C Arul Venkadesh	Organizational Factors influencing Safety (F2)	India	Reduce the level of impact of disaster through Safety Management Plans and aim for a threat free environment
27.	Safety Management Systems (SMS) and	2011	Dr R Kauppasamy &	Human/ Individual Factors influencing	India	Safety Management System provides set of procedures to

	its implications		Sh. C Arul Venkadesh	Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)		assist in identification and mitigation of hazards ultimately aiming towards development of better safety culture.
28.	The differentiation and decision matrix risk assessment of accident precursors and near-misses at construction sites	2012	QiangChem, Weiwei & Xing Zhang	Incident Accident Investigation & Analysis (F5)	USA Technological Disaster	Information from precursors and near miss incident investigations becomes important tool of risk communication and helps improve safety margins.
29.	Mitigation Strategies of Safety Management	2013	Dr R Kauppasamy & Sh. C Arul Venkadesh	Safety Culture in Organization (F4)	India	Expert group to plan and implement safety management system and processes play vital role in mitigation and containment of risks.
30.	The 319 Major Industrial Accidents Since 1917	2012	Efthimia K. Mihailidou, Konstantinos D. Antoniadis & Marc J. Assael	Incident Accident Investigation & Analysis (F5)	Worldwide	Better enforcement of safety regulatory legislation enhances level of safety and decreases industrial accident rate.
31.	A systematic review of the effectiveness of safety management systems	2012	Dr. Matthew & J W Thomas	Organizational Factors influencing Safety (F2)	Australia Transport Sector	In normal business operations of high-risk industries, safety management system does seem to reduce accidents and enhance “safety”.

32.	Model of Accident Causation	2012	Safety Institute of Australia	Incident Accident Investigation & Analysis (F5)	Australia	A review of Accident Causation Model and its effectiveness in SMS.
33.	Safety Culture	2013	Ruoyu Jin and Qian Chen	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)		Holistic approach in assessing safety culture based on an integrated model is helpful in ensuring effectiveness of safety programs.
34.	"Recent trends in Safety Management System in Carbon Disulphide Plant"	2013	Shweta Chittora & Dr. Anjani K Dwivedi	Organizational Factors influencing Safety (F2)	Carbon Disulphide Plant, India	Assessment of occupational hazards and risks management is important to achieve zero work related illnesses.
35.	Road Safety Management – Application of advance techniques and equipments in India	2013	T Sivakumar, Dr R Krishnaraj	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2)	India	Advancement of latest technology with right blend of enforcement and education of road safety rules would result in reduction of accidents.
36.	Measuring construction site safety in Kolkata, India	2013	Himadi Guha, & Partha Pratim Biswas	Organizational Factors influencing Safety (F2)	Construction India	Absence of safety culture amongst community, is one of the reasons for safety lapses in the construction sites.

37.	Senior managers and safety leadership role in offshore oil and gas construction projects	2017	Tarila Zuofaa & Edward G. Ocheingb	Organizational Factors influencing Safety (F2)	Offshore Oil & Gas UK	Role of senior managers in various off shore installations of Oil & Gas sector is found to be significant. Leadership approach plays major role in the success or failure of "Safety Management System" implementation especially during construction.
38.	Structuring critical success factors of airline safety management using a hybrid model.	2010	Yueh-Ling Hsu, Wen-Chin Li & Kuang-Wei Chen	Developing Safety Management System (F6)	Airline, Asia	Development of Performance related Safety Management Processes are key for achieving effective safety management.
39.	Building an effective safety management system for airlines	2008	James J.H Liou, Leon Yen & Gwo Hshiung Tzeng	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3) Developing Safety	Airlines, Asia	Strategy, policy implementation and human factor are three elements of triangle whereas monitoring and feedback play key role in SMS.

				Management System (F6)		
40.	Factors affecting the planning and implementation of Occupational Health and Safety Management System	2000	Leung Kam Tak	Organizational Factors influencing Safety (F2) Developing Safety Management System (F6)	Asia	This paper outlines that "Safety" should be integrated with management system to form system of effective planning and implementation of Safety Management System.
41.	Factors influencing Safety Management System in Petrochemical Processing Plants	2017	Norfaridatual Akmaliah Othman, Juhani Jabar, Murzidah Ahmad Murad & Mohd Fauzi Kamarudin	Organizational Factors influencing Safety (F2)	Malaysian	This paper thrusts on understanding on formulation of SMS along with its influencing factors and implementation during construction of processing plants.
42.	The effectiveness of occupational health and safety management system interventions: A systematic review	2006	Lynda S. Robson, Judith A. Clarke, Kimberley Cullen, Amber Bielecky, Colette Severin, Philip L. Bigelow, Emma Irvin, Anthony Culyer & Quenby Mahood	Developing Safety Management System (F6)	Worldwide	This logical literature review was intended to assess various evidences so as to establish financial and other (Health & Safety related) impacts in relation to OHSMS implementation.
43.	A Mini Review on Efficacy of Safety Management	2017	Ahmed Suan	Developing Safety Management System (F6)	United Arab Emirates	This study outlines discussion on safety management system processes and sub processes. It

	Systems in Construction					also establishes correlation between safety management system implementation and safety performance by periodic evaluation and analysis.
44.	A study on accident theories and application to maritime accidents	2016	Zobair Ibn Awal & Kazuhiko Hasegawa	Incident Accident Investigation & Analysis (F5)	Worldwide	This paper provides a comprehensive review to compare various accident theories/models along with their attributes for maritime accidents.
45.	Repairs as the last orderly provided defense of safety in aviation	2010	IIkka Arminem, Petra Auvinen & Hannele Palukka	Human/ Individual Factors influencing Safety (F1)	US	Through this paper, relationship has been established between Reason's Swiss Cheese Model and aviation safety management taking account of the types of work processes including the failures and troubles.
46.	Multiple food safety management systems in food industry: A case study	2018	Muhammed Rafeeque KT, Mini Sekharan N	Developing Safety Management System (F6)	Maldives	This paper detailed with the aim to analyse the motivations for the adoption of MFSMS and the consequences of that adoption in the management system and the organization.
47.	Systems thinking, the Swiss Cheese Model and accident analysis: A comparative systemic analysis	2013	Loughborough University	Developing Safety Management System (F6)	Worldwide	This paper deals with Safety Accident Analysis and Swiss Cheese Model for their effectiveness
48.	Procedures coming	2016	Thomas Wold	Human/ Individual	Offshore Oil &	This paper focusing on

	every day: Safety Management Systems and safety communication in high-risk industries			Factors influencing Safety (F1)	Gas	establishing training system in Petroleum Industries for effective implementation of Safety Management System. Different types of training system should be developed in different organizations to understand various safety processes.
49.	Safety Management Systems - Definitions, challenges for use and recommendations for improvements.	2015	Thomas Wold & Karin Laumann	Developing Safety Management System (F6)	Worldwide	The paper outlines the purposes of leveraging IT in Safety Management System to create knowledge data base, which can be shared and analyzed for increasing effectiveness of SMS.
50.	Safety Management Systems as communication in an oil and gas producing company	2014	Thomas Wold & Karin Laumann	Developing Safety Management System (F6)	Norway	The paper examined the usage of IT based applications in “safety management system”. It advocated that IT based safety processes should be used as communication tool in organizations which will facilitate analysis of safety processes along with dissemination of safety knowledge.
51.	End User Involvement in the Development of Procedures and Safety Management	2014	Thomas Wold & Karin Laumann	Human/ Individual Factors influencing Safety (F1)	Norway	On Shore & Off Shore Oil Companies should involve working level operators/supervisors while drafting Safety procedures and processes.

	Systems					
52.	From theory to practice: itinerary of Reason's Swiss Cheese Model	2015	Justin Larouzee, Franck Guarnieri	Developing Safety Management System (F6)	Worldwide	Applicability of Swiss Cheese Model is found to be relevant in today's environment for accident prevention?
53.	Human Factors Analysis and Classification System Interrater Reliability for Biopharmaceutical Manufacturing Investigations	2015	Roberto Cintron Walden University	Human/ Individual Factors influencing Safety (F1)	Worldwide	Paper relates to Human error investigations in bio pharmaceutical industry.
54.	Implementation of an integrated management system into small building company	2014	Andrea Parisi Kern	Developing Safety Management System (F6)	Brazil	In the construction companies, systems of quality management, environment management and occupational health and safety management should be integrated with planning, processes and production.
55.	Relationship between latent conditions and the characteristics of holes in marine accidents based on the Swiss Cheese	2015	Koji Fukuoka & Masao Furusho	Developing Safety Management System (F6)	Japan	In this paper 86 marine incidents were studied to find out relationship between latent conditions and the holes, called as accident opportunities in Swiss Cheese Model.

	Model					
56.	Preliminary study for modeling train accidents in Indonesia using Swiss Chees Model	2015	Muhammad Ragil Suryoputro, Amarria Dila Sari, Ratih Dianingtyas Kurnia	Developing Safety Management System (F6)	Indonesia	Through Swiss Cheese Model, accidents can be investigated to determine root causes and find solution by simulations.
57.	Modified Swiss Cheese Model to Analyze the Accident	2015	Mehmodd Ahmad & Marco Pntiggia	Developing Safety Management System (F6)	Worldwide	Revised Swiss Cheese Model can also be applied as a safety barrier in order to augment the available resources in addition with study an accidental situation for determining root causes.
58.	Human and Organizational Factors in Major Accident Prevention	2016	Kat Robertson, James Black, Sarh Grand-Clement & Alexandra Hall	Human/ Individual Factors influencing Safety (F1)	Europe	This paper outlines the characteristic of human and organizational factors in major accident prevention in Oil & Gas.
59.	Practical implementation of safety management systems at Unregulated Upstream Oil & Gas Facilities	2013	Kristin D Norton Michael B Saura & Colin R Scholtz	Developing Safety Management System (F6)	Worldwide	Practical implementation of safety procedures and processes requires pre-planning and establish the Process Safety Management as a part of the overall management approach.
60.	Improving safety performance by understanding relationship between management practices and leadership behavior	2011	Wameedh A Khadair, Faridahwati Mohd shamsudin & Chandrakantam Subramanim	Safety Culture in Organization (F4)	Iraq	The role of two key organizational factors i.e Management Practices and Leadership Behaviour that may be having an influence on safety performance of Oil & Gas Industry, has been studied.

	in the Oil & Gas Industry					
61.	A need for new theories, models and approaches to occupational accident prevention?	2008	J. Hovden E., Albrechtsen, I.A. Herrera	Developing Safety Management System (F6)	Worldwide	Occupational accident modelling needs to be developed in this changing for high-risk which includes larger interaction with people and technologies can be converted and improved to occupational accident prevention.
62.	Prioritizing the safety management elements	2006	W.K. Law and A.H.S. Chan, K.F. Pun	Developing Safety Management System (F6)	Hong Kong	In manufacturing enterprises, effective implementation of "safety management systems" requires addressing of identification of core decision principles and essentials of safety programs.
63.	Human Factors		Thomas B. Sheridan	Human/ Individual Factors influencing Safety (F1)	USA	This paper outlines probabilistic risk analysis on past error events to identify system vulnerabilities with respect of human error.
64.	A Human Factors Perspective on Safety Management Systems		Christopher Lowe	Human/Individual Factors influencing Safety (F1)	UK	Human Factors issues which influence Safety Management has been discussed. This requires systemic approach, and investigation methodology to identify barriers and opportunities while incorporating human factors in high risk industry's Safety Management System. .

65.	Safety climate, safety management practice and safety performance in offshore environments	2003	Kathryn Mearns, Sean M. Whitaker & Rhona Flin	Safety Culture in Organization (F4)	UK	A cross-organisational appraisal system should developed to identify best safety practices and further benchmark the process for continual improvement.
66.	Methods and models in process safety and risk management: Past, present and future	2014	Faisal Khan, Samith Rathnayaka & Salim Ahmed	Developing Safety Management System (F6)	Worldwide	The review paper summarizes to adopt dynamic risk assessment and management process instead of conventional risk assessment. This also suggested decisions may be taken based on risk rather than hazard based.
67.	Problems and Strategy of Construction Safety Management	2014	Hao-Sen SUN1,a, Dong YANG2,b, Shi-Jun WEI1,c,*, Qing-Mei WEN1,c	Developing Safety Management System (F6)	Worldwide	Using the experience of the safety management in developed countries as reference, the characteristics and the difficulties of safety management of construction projects should be analysed.
68.	Perception Gaps in the Execution of Safety Management System–A Case Study of the Airline Industry	2011	Ching-Fu CHEN & Shu-Chuan CHEN	Developing Safety Management System (F6)	Taiwan	In the airline industries it has been found that there was large gap between fist line employees and first level supervisors in understanding and execution of safety management system.
69.	Performance evaluation of airport	2013	Yu-Hern Chang, Pei-Chi Shao &	Developing Safety Management System	Taiwan	This paper briefed about establishing the airport SMS

	safety management systems in Taiwan		Hubert J. Chen	(F6)		performance evaluation system, experience sharing (of safety management) with peer airports; improving overall effectiveness of airport SMS
70.	Relationships between accident investigations, risk analysis, and safety management	2004	Lars Harms – Ringdahl	Organizational Factors influencing Safety (F2)	Worldwide	This paper outlines various inter relationships between safety management system, accident investigation and risk analysis in organization.
71.	Behavioural approaches to safety management within UK reactor plants	2004	Sue Cox, Bethan Jones & Helen Rycraft	Safety Culture in Organization (F4)	UK	Behavioural approaches to safety management has been established for employees working in UK reactor plants
72.	Design and first development of an automated real-time safety management system for construction sites	2009	Alberto Giretti, Alessandro Carbonari, Berardo Naticchia & Mario DeGrassi	Human/ Individual Factors influencing Safety (F1)	Worldwide	This paper reports about Ultra Wide Band a new advance system which can automatically track health and safety management processes of construction workers on real time basis and prevent un authorized access on construction sites.
73.	A new conceptual framework to improve the application of occupational health and safety management systems	2007	A.M. Makin & C. Winder	Developing Safety Management System (F6)	Australia	This paper talks about accurately determining and understanding the business operations and various risk factors, which have great impact on health and safety. Without above understanding

						compliance audit will not be effective.
74.	Occupational health and safety management in organizations: A review	2012	Michael Zanko & Patrick Dawson	Developing Safety Management System (F6)	Worldwide	This paper argues that the increase in the number of experts in occupational health and safety has resulted in an emphasis on policy and practice. However, there is a need to correlate occupational health and safety with human resource management.
75.	Human Factors Analysis and Classification System Interrater Reliability for Biopharmaceutical Manufacturing Investigations	2015	Roberto Cintron	Human/Individual Factors influencing Safety (F1)	Worldwide	In biopharmaceutical manufacturers, the study outlines the process to minimize errors of human by improving the safety and dependability of their processes with improved root cause analysis.
76.	From the traditional concept of safety management to safety integrated with quality	2001	Susana Garc, Herreroa, Miguel Angel Mariscal Saldan, Miguel Angel Manzanedo del Campoa & Dale	Developing Safety Management System (F6)	Spain	Principles of Total safety management were discussed in detailed with an analysis having relationship between quality and safety. Accordingly, safety management system should be based on quality of processes.

			O. Ritzel			
77.	Developing a Model of Construction Safety Culture	2007	Rafiq M. Choudhry, Dongping Fang and Sherif Mohamed	Safety Culture in Organization (F4)		Aspects of individual, technical, situational and organizational should be considered for developing safety culture model.
78.	Safety Management in Construction: Best Practices in Hong Kong	2008	Rafiq M. Choudhry, Dongping Fang and Syed M. Ahmed	Developing Safety Management System (F6)	Hong Kong	This paper describes safety management processes in construction sites' environments by an empirical study. It deliberates on various aspects of "health and environmental management system" requirements for a leading construction company.
79.	Major Theories Of Construction Accident Causation Models: A Literature Review	2012	Seyyed Shahab Hosseinian & Zahra Jabbarani Torghabeh	Developing Safety Management System (F6)		By focusing on individual characteristics, management approaches and physical characteristics of hazards common accident causation theories were reviewed.
80.	Management of health, safety and environment in process industry	2007	Nijs Jan Duijm a,*, Ce´cile Fie´vez b, Marko Gerbec c, Ulrich Hauptmanns d, Myrto Konstandinidou e	Developing Safety Management System (F6)	UK	It is believed that target and goal based safety programmes are to be more effective make organization's profitable. However, such processes and standards adopted by industry should be reviewed.

81.	Perspectives on safety culture	2000	A.I. Glendon & N.A. Stanton	Safety Culture in Organization (F4)	Worldwide	The paper outlines the differences between `culture' and `climate' as they are typically applied to organisations and to safety.
82.	Leading indicators of system safety – Monitoring and driving the organizational safety potential	2011	Teemu Reiman & Elina Pietikäinen	Safety Culture in Organization (F4)	Worldwide	This paper outlines theoretical framework for using indicators of safety performance of organizations. Such performance indicators should be of – outcome, monitor and drive indicators
83.	The relationship between employees' perceptions of safety and organizational culture	2001	Michael O'Toole	Safety Culture in Organization (F4)	Worldwide	There is a correlation between safety approach adopted b management and employees' perception of safety. It is very important that how these aspects are being managed?
84.	Safety Management – Looking Back or Looking Forward		Erik Hollnagel	Developing Safety Management System (F6)	World	This paper provides a control engineering perspective to safety management and in that way identified five fundamental issues that can be used to provide a generic characterisation of any kind of SMS, reactive as well as proactive

85.	Factors influencing the implementation of a safety management system for construction sites	2011	Zubaidah Ismail, Samad Doostdar, Zakaria Harun	Human/ Individual Factors influencing Safety (F1) Organizational Factors influencing Safety (F2) Environmental Factors influencing Safety (F3)	Malaysia	Improve the competence and productivity of construction workers equipment/facility design and improved work practices and processes has been discussed.
86.	Beyond the organisational accident: the need for ‘‘error wisdom’’ on the frontline	2004	J Reason	Human/ Individual Factors influencing Safety (F1)	Worldwide	The paper has focused on the aspects of human error and how it can be managed. In medical sector, it proposed that error wisdom can be reduced by use of some mental skills by hospital staff at large extent.
87.	Site managers and safety leadership in the offshore oil and gas industry	2001	A. O'Dea & R. Flin	Organizational Factors influencing Safety (F2)	UK	The paper investigates the behavioural aspects with safety attitudes of managers. It also correlate behaviour in relationship managers’ knowledge and style of leadership. It summarized that managers' perceptions of best practice in safety leadership and their beliefs is key to resolve safety issues.
88.	The Application of Benchmarking Management on Safe	2012	Gao Xinga, Ma Yingnana & Zhang Qiujie	Safety Culture in Organization (F4)	China	There is a need to identify key performance indicators for development of safety

	Community					benchmarking. This should be developed based on carefully examined the internal and external data & analysis. Accordingly, such benchmarking will help in continuous improvement.
89.	Construction Safety Benchmarking	2006	Abdul Rahim Abdul Hamid and Muhd Zaimi Abd Majid	Safety Culture in Organization (F4)	Malaysia	Benchmarking considered as an improvement tool which can be used to any area of an organisation's activity. Safety benchmarking is about identifying standards which are key to safety performance in a company and comparing these against the performance of other companies.
90.	A Review on the Benchmarking Concept in Malaysian Construction Safety Performance		Nurfadzillah Ishak and Muhammad Azizi Azizan	Safety Culture in Organization (F4)	Malaysia	By using the right benchmarking process on peer's best practices, to be implemented to improve quality of safety programs.
91.	Introduction to HSE Benckmarking	2011	A. Kay	Safety Culture in Organization (F4)	UK	The primary benefit is a performance improvement that leads to a reduction in HSE incidents. Benchmarking is not a 'quick fix' and should be judged over the longer term.
92.	Relative Culture Strength	2007	Mike Hewitt	Safety Culture in Organization (F4)	Worldwide	In order to understanding of key elements to develop an organization which demonstrates sustainable world-class safety

						performance.
93.	OHS Performance Indicators for Benchmarking	2002	Andrea Shaw	Safety Culture in Organization (F4)	Australia	This paper is used as a means of promoting OHS performance by using leading and lagging indicators for benchmarking.

2.3 GAPS IN LITERATURE

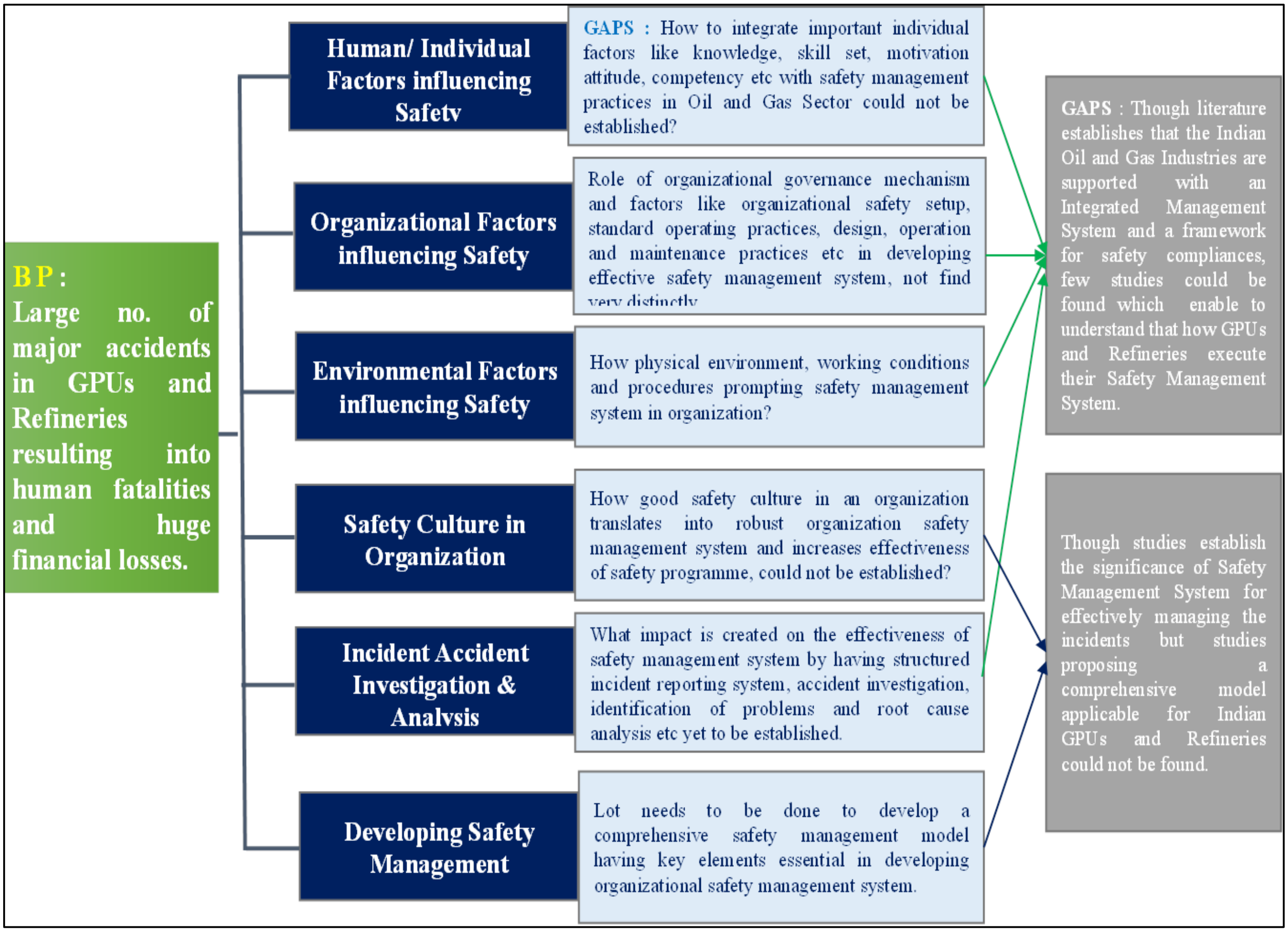


Figure 2.3.1 – Literature Gaps

In most of the literatures reviewed, Safety Management System and their processes have been discussed for effective implementation. Some examples are such as Organizational, Environmental and Individual Factors influencing safety, development of safety management, safety culture, incident investigation and analysis etc for a particular industry in countries like UK, USA, Asia, Scotland, France, Ireland, Swedish, Australia, India etc.

As on date various literatures available in the databases such as Science direct, IEEE etc. (with the following key words safety management, safety culture, models of safety management, human factor in safety, factors influencing safety, accident causation etc., study of safety management system) do not give any search result on Development of Safety Management System Model in Oil and Gas/Gas Processing Plants in India.

Based on above literature review, the gaps in literature can be summarized as given below:

1) Studies have been carried out worldwide on Safety Management System in the field of Maritime, Steel, Oil & Gas, Petrochemical Processing Plant, Airlines, Transport Section, Hospital etc. but no comprehensive study was done taking into account factors of Safety Management System in Gas Processing Plants and Refineries in India, as identified.

2) Though studies establish the significance of Safety Management System for effectively managing the incidents but studies proposing a comprehensive model applicable for Indian GPUs and Refineries could not be found.

2.4 THEORETICAL PREMISE

In order to successfully develop and manage an effective Safety Management System, it was required to understand the various causes of the accident. In earlier days of onset of Industrialization, it was believed that those workers who get involved in accidents, do not remain careful. This was very easy and simple explanation, because nothing was required to be done by managers under those circumstances. It was believed that it is people responsibility to protect themselves from any accident and "people always had been and always would be careless".

Further, since human nature could not be changed, it was accepted that accidents could be naturally happening along with production and were "side effect of production".

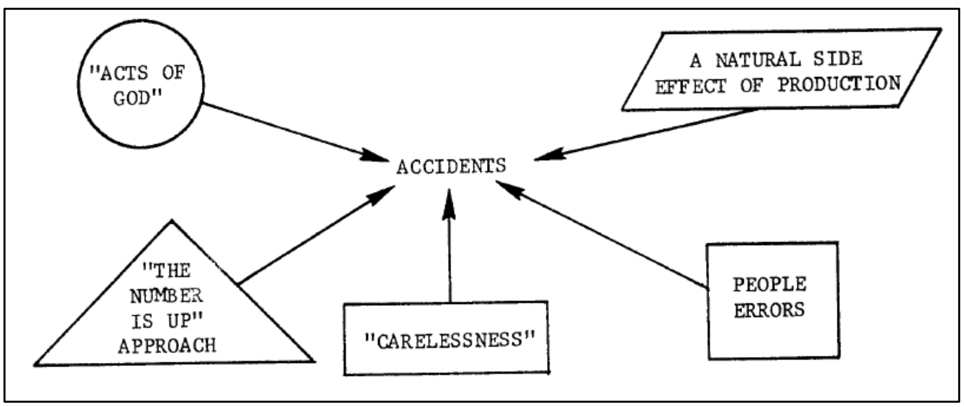


Figure 2.4.1 – Accident Causation Model

2.4.1 ACCIDENT CAUSATION DOMINO THEORY BY HEINRICH

Accident causation theories were first given by Heinrich, detailing various relationships between man, machine, incident frequency and severity, various reasons of unsafe acts at work, financial impact of accidents and role of management in preventing accidents etc. Based on accident statistics Heinrich informed that "88 percent of accidents are due to unsafe act of workers, 10 percent due to unsafe conditions and 2 percent of all accidents are associated with act of God, such as natural disasters". According to his assessment, he defined accident as "an unplanned and uncontrolled event in which the action or reaction of an object, substance, person, or radiation results in personal injury or the probability thereof".

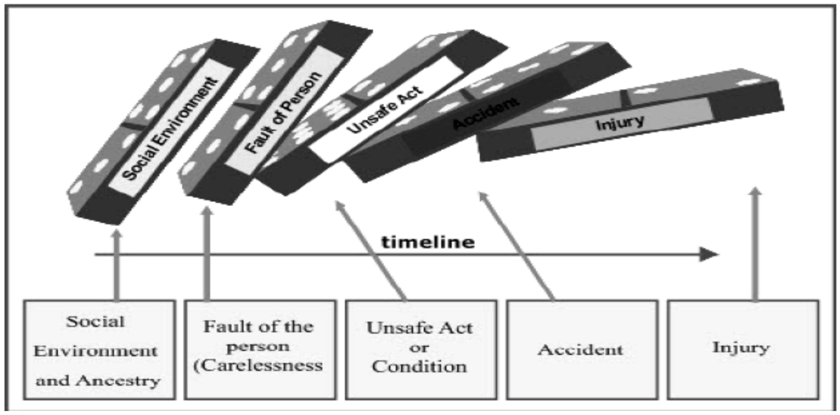


Figure 2.4.2 – Heinrich Domino Theory of Accident Causation

2.4.2 MULTIPLE CAUSATION MODEL (PETERSEN, 1971; NON-DOMINO-BASED MODEL)

The Heinrich domino theory is primarily based on the concept that an accident may be caused by one single cause. In 1971, Petersen came up with a model which was based on 'management system' instead of an individual. Petersen suggested that there are two main cause of the events which could cause an accident i.e an "unsafe act" and an "unsafe condition". He further suggested that three were always one cause which contribute or lead to both "unsafe act" and "unsafe condition" and ultimately accident happens. Domino theory simply talks about "causes" and "sub causes" which lead to an accident. Whereas, as per "Multi Causation Model", many contributory factors lead to an accident. If those causes of accidents are identified, one can prevent "unsafe acts" and "unsafe conditions".

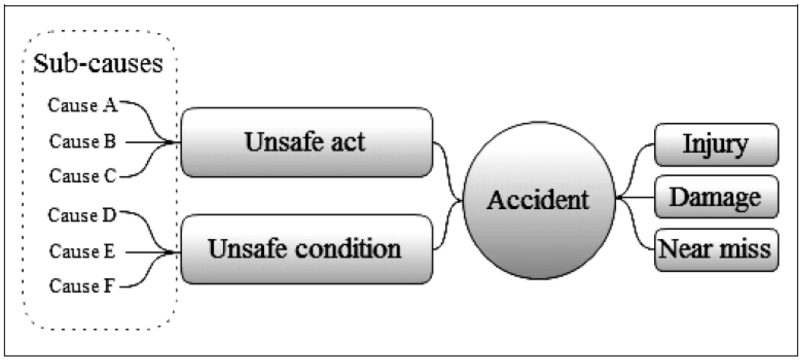


Figure 2.4.3 – Multiple Causation Model by Peterson

2.4.3 UPDATED DOMINO SEQUENCE

To identify important role of "management system" in accident causes, Bird and Loftus modified the "Domino theory" given by Heinrich during 1974. As per them

"The updated and modified sequence of events is:

- Lack of control/management (inadequate program, inadequate program standard, inadequate compliance to standard)
- Basic causes/origins (basic causes: 1-personal factors, 2-job factors)
- Immediate causes/Symptoms (sub-standard act and condition)
- Incident (contact with energy and substance)
- Loss (property, people, process)"

"The updated domino sequence can be used and applied to all types of accidents and is fundamental in loss control management".

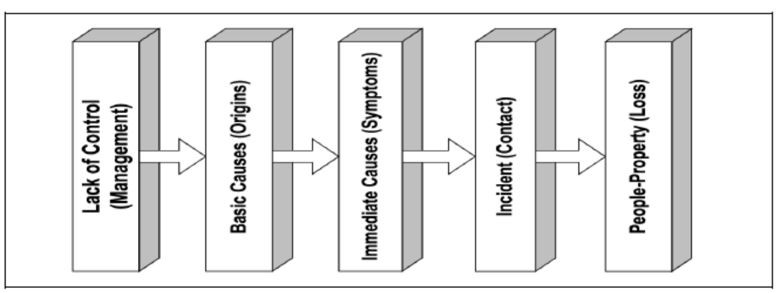


Figure 2.4.4 – Updated Domino Based Model given by Bird and Loftus (1974)

2.4.4 BEHAVIOR MODELS

Some of the models were based on human behavior. In that approach, it was believed that "human error" may occur under different work environments. Human being were considered responsible for their "unsafe behavior" at work. As per Rigby (1970) human error can be defined as "anyone set of human actions that exceed some limit of acceptability". Behavior models were based on the "Accident Proneness Theory". As per theory some people have individual characteristics which make them involved in various accidents. Many behavior models were prescribed by researchers so as to indicate towards the reasons for "accident repeaters", such as the "Goals freedom alertness theory" (Kerr 1957) and the "Motivation reward satisfaction model" (Petersen 1975).

2.4.5 FERREL THEORY

During 1997 Doctor Russel Ferrel came up with his "theory of accidents" based on a chain of human factors/causes. He suggested that the "human errors" were the real causes of accidents. As per him human errors were caused by following factors:

- "Overload; the overload factor reflects the incompatibility between the load and the capability of the human. The result of this mismatch is anxiety, pressure, fatigue and emotions that can be intensified by physical environment such as dust, light, noise, fumes etc. where the person is working.
- Incorrect response; the incorrect response by the person is caused by the incompatible situation where he/she is working in.
- Improper activity; the person performs the activity improperly either due to lack of knowledge of appropriate way of performing the activity, or intentionally take the risk".

Physical environment (i.e. light, noise, dust) → Mental capability

↓

Incompatibility or mismatch (Physical environment - Mental capability) if exist

↓

Overload (Anxiety - pressure - fatigue - emotions)

↓

Incorrect response

↓

Improper activity by the person

↓

Accident

Figure 2.4.5 – Ferrel Theory

2.4.6 THE 'SWISS CHEESE' MODEL

Reason's was involved in in-depth study in the field of psychological error mechanisms. This study was found significant in the discussion on complexity of accident causation. By analyzing everyday slips and lapses he developed models of "human error mechanism".

As per James Reason, professor of Manchester University, "Trigger point for accident sequence is the corporate culture. Local conditions and behavior at work only contribute in development of undesired event". As per Swiss Cheese Model, system's defense and barriers are penetrated because of latent organizational failures, leading to accident or incident. The intervening barriers between local hazards and potential losses shown as cheese slices. Each cheese slice denotes one layer of defense.

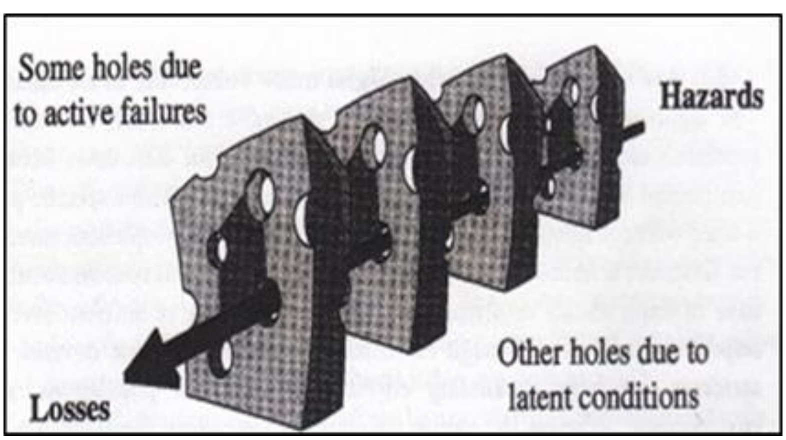


Figure 2.4.6 - Swiss Cheese Model I

In ideal situation, all layers of cheese will be intact. In real word, each cheese layer has some holes/ gaps. Active failures lead to such gaps. Designers, builders and managers etc. commit many errors in anticipating various possible situations, leading to latent conditions, which also ultimately create such gaps. The holes/ gaps created by active failures are generally for short period of time, whereas those created due to latent conditions may continue to remain in the system for long time unless they are detected by various auditors, regulators or during real time accident/ incident. Those defensive gaps, especially those created due to active failures keep moving around. Those gaps open and close as per the prevailing circumstances. This process also explains as to why accidents happen rarely in the organizations. When holes get lined up in a straight line, an opportunity of accident event gets created.

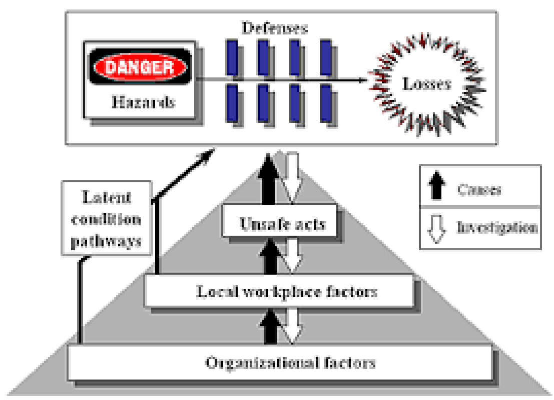


Figure 2.4.7 Swiss Cheese Model II

'Corporate Culture', 'Organizational Processes' and 'Management Decisions' were part of "Organization" vertical. Those times were such when 'safety culture' and its importance were getting established. Above model was indicating towards requirement of multiple failures for an accident to occur. Single failures like 'Human' or 'Technical' were not enough to cause an accident, as per the model. Many factors which could not be foreseen could be coincidently causing accident opportunity. Such theory of James

Reason gained popularity and appeared to be having universal relevance in various facets of business.

The Swiss cheese model of accident causation is a model used in risk analysis and risk management. This model in also widely accepted in emergency service organizations, aviation safety, engineering, healthcare and as the principle behind layered security, as used in computer security and defense in depth.

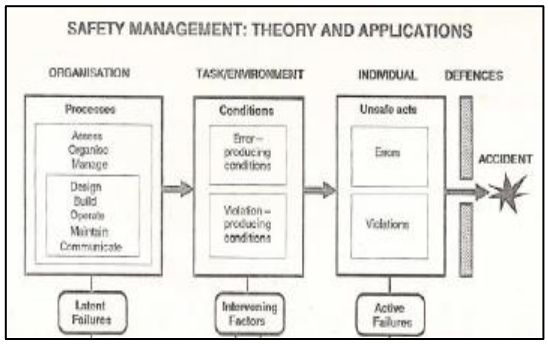


Figure 2.4.8: Reason - Safety Management Theory and Applications

The Safety Management Theory and Application “Mark II model” was developed by James Reason in the early to mid-1990s. Through a construct, James Reason described co-relation of three different factors: the organization, workplace/condition/environment and person or individual in a ‘Safety Management System’, as shown above. In this Safety Management: Theory and Applications, Organizations Failures, Task/Environment conditions and Individual errors were considered as Latent Failures, Intervening Failures and Active Failures respectively, which are primarily responsible for accident causation.

LITERATURE REVIEW ON THEORETICAL PREMISE

Table 2.4.1

SN	Context	Year	Study/ Author	Context Country/ Industry	Variables Identified	Key Themes	Gaps
1.	Theories of Safety Management	1979	Safety Management Concept Series	United State Army	Accident Investigation & Developing Safety Management	Factors for developing or designing safety management/programme to eliminated rooted cause of human/operator error.	--
2.	From theory to practice: itinerary of Reasons' Swiss Cheese Model	2015	Justin Larouzee, Frank Guarnieri	France	Accident Investigation & Developing Safety Management	This paper outlines whether the SCM is relevant in accident prevention or explanation.	One may further research and to through many cases so as to understand James Reason's theory and swiss cheese model. Not relevant to GPUs and Refineries.
3.	System thinkg, the Swiss Cheese Model and Accident Analysis	2013	Underwood P, Waterson P	Australia	Accident Investigation & Developing Safety Management	This paper deals with Safety Accident Analysis and Swiss Cheese Model for their effectiveness	The study recommends that SCM relics practical model for understanding accidents specifically in ATSB.
4.	Preliminary study for modeling train accidents using Swiss	2015	Muhammad Ragil Suryoputor, Amarria Dila Sari, Ratih Dainingtyas	Indonesia	Accident Investigation & Developing Safety Management	This paper deals with finding explanation through identifying the root causes to prevent the incidents.	The swiss cheese model could be further researched so as to make it more user friendly and customized for its application in "Accident

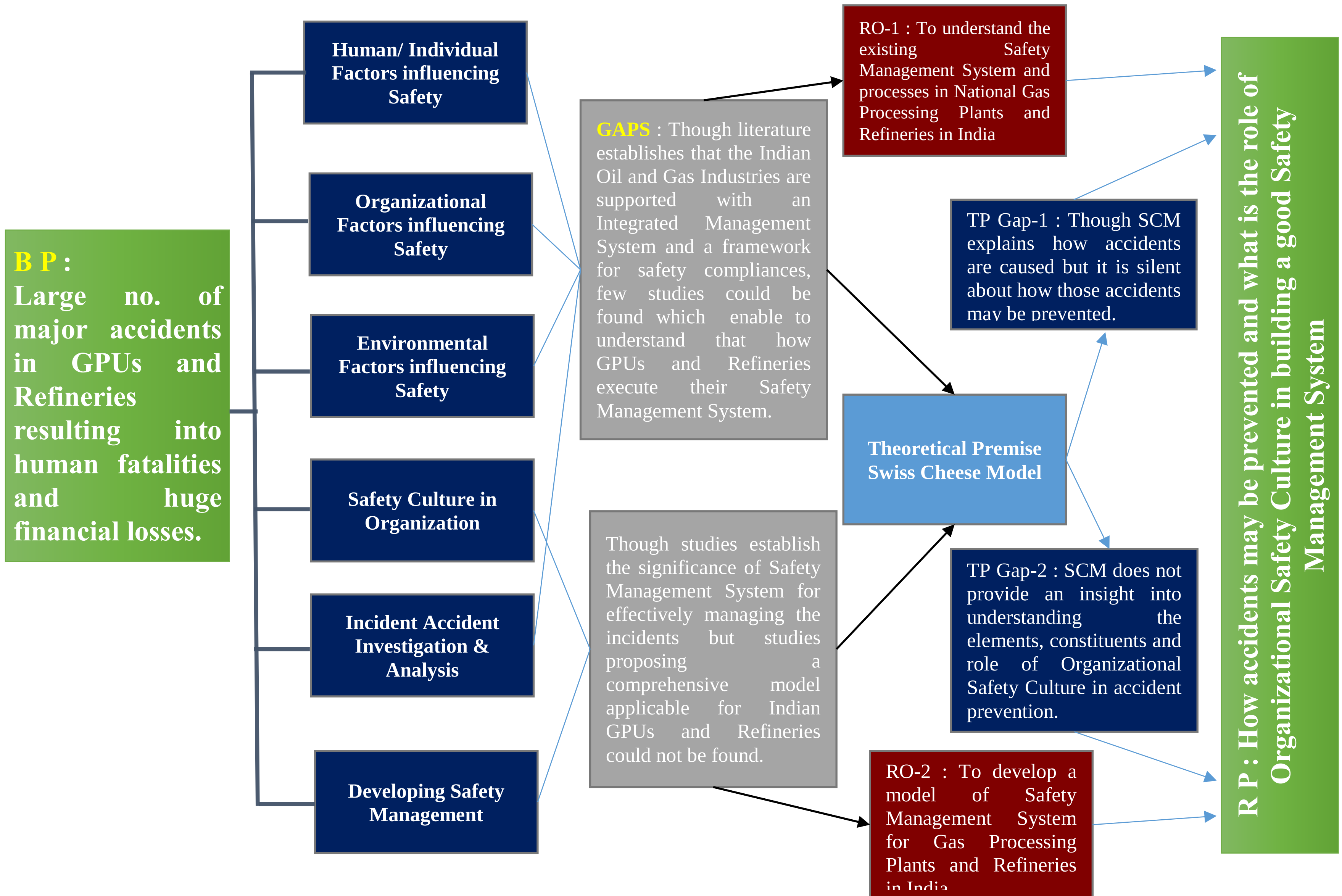
	Cheese Model		Kurnia				Investigations".
5.	Modified Swiss Cheese Motel to Analyze the Accident	2015	Mehmood Ahmad & Marco Pontiggia	Worldwide	Accident Investigation & Developing Safety Management	Revised Swiss Cheese Model can also be applied as a safety barrier in order to augment the available resources in addition with study an accidental situation for determining root causes.	To better understand interaction between operator and equipment/machines, SCM could be utilized proactively, in addition to its usage for post incident learnings.
6.	Revisiting the "Swiss Cheese" Model of Accidents	2006	Eurocontrol Experimental Section	Air Navigation, France	Accident Investigation & Developing Safety Management	There is a need to explore incident/accident model further or to develop comprehensive theory as to "how the multitude of functions and entities in a complex socio-technical system interact and depend on each other".	There is a gap with respect to detailed explanation and interlinkage of multiple functions and factors in complex environment, when we see swiss cheese model and its theory.
7.	Relationship between latent conditions and the characteristic of holes in marine accident based on Swiss Cheese	2015	Koji Fukuoka & Masao Furusho	Japan	Accident Investigation & Developing Safety Management	In this paper 86 marine incidents were studied to find out relationship between latent conditions and the holes, called as accident opportunities in Swiss Cheese Model.	--

	Model						
8.	A study on Accident Theories and Application to Maritime Accidents	2016	Zobair Ibn Awal & Kazuhiko Hasegawa	Maritime Industries	Accident Investigation & Developing Safety Management	This paper discussed the aspects of analyzing and understanding accidents and its prevention by introduction and usage of an innovative technique.	Further, work be done for developing new techniques of logic programming so as to resolve many problems arising out of maritime accidents.
9.	The Swiss Cheese Model of safety incidents are there holes in metaphor?	2005	Thomoas V Perneger	Patient Safety	Accident Investigation & Developing Safety Management	The study provides interpretation of various component of Swiss Cheese Model by expert safety professionals differently.	This study is limited to Patient Safety Incidents.
10.	Achieving a safe culture: theory and practice	1999	James Reason	UK	Safety Culture in Organization	The need for an organization to develop safety culture, which consists of number of interacting elements or ways of doing, thinking and managing those factors which enhance resistance to operational dangers.	--
11	Swiss Cheese and a Cheesy CMB	2009	Wessel Valkenburg	Worldwide	Accident Investigation & Developing Safety Management	This paper describes the applicability of Swiss Cheese Model for cosmic microwave background.	--

Table 2.4.2: Key Themes Literature Review

SN	Theme	Author	Context/Country	Inferences	Gaps
1.	Developing Safety Management	Safety Management Concept Series, Justin Larouzee, Frank Guarnieri, Underwood P, Waterson P, Muhammad Ragil Suryoputor, Amarria Dila Sari, Ratih Dainingtyas, Mehmood Ahmad, Marco Pontiggia, Eurocontrol Experimental Section, Koji Fukuoka, Masao Furusho, Zobair Ibn Awal, Kazuhiko Hasegawa, Thomoas V Perneger,	USA, France, Australia, Indonesia, Worldwide, Japan	SCM seems one of the evolved model for investigation of incidents and root cause analysis. Identified root causes are found significant in developing safety programme.	Though SCM explains how accidents are caused but it is silent about how those accidents may be prevented.
2.	Safety Culture	James Reason	UK	Ruthless safety culture leads to an atmosphere of non-compliance to safety processes/procedures Also, culture can affect the slices of cheese.	SCM does not provide an insight into understanding the elements, constituents and role of Organizational Safety Culture in accident prevention.

Figure 2.4.9: Defining Research Problem



CHAPTER 3.0: RESEARCH DESIGN & METHODOLOGY

3.1 PROBLEM STATEMENT

How accidents may be prevented in national Gas Processing Plant and Refinery in India and what is the role of organizational Safety culture in building a good Safety Management System.

3.2 RESEARCH OBJECTIVES

The specific objectives of the research work are:

1. To understand the existing Safety Management System and processes in National Gas Processing Plants and Refineries in India.

2. To develop a model of Safety Management System for Gas Processing Plants and Refineries in India.

3.3 RESEARCH QUESTIONS

RQ1: How National Gas Processing Plants and Refineries plan and execute their SMS and related processes to ensure safety in operation and maintenance?

RQ2: What should be the comprehensive Safety Management Model applicable to Indian GPUs and Refineries?

3.4 OVERALL APPROACH & RATIONALE OF THE STUDY

"In management research, the researcher is intrigued with a problem or phenomenon in practice, which the researcher wants to explore and understand" (Maxewell, 1996). Then research questions and a research design is developed by researchers to thoroughly understand this problem/phenomenon. For developing a conceptual lends o as to study the problem, existing theory is further explored and taken along, utilizing “theory development methodology”. The research questions and developed conceptual lens lead to the formulation of “empirical research design and data analysis approach”. Thereafter one enters the “empirical world”, makes desired observations keep collecting data. The Data so collected is managed and analyzed taking into account the “conceptual lens” and “empirical research design” which ultimately takes you to findings. Those findings may guide you to extension of existing theory, helping in understanding and prescribing problem. This research design has been shown in the Figure -3.4.1.

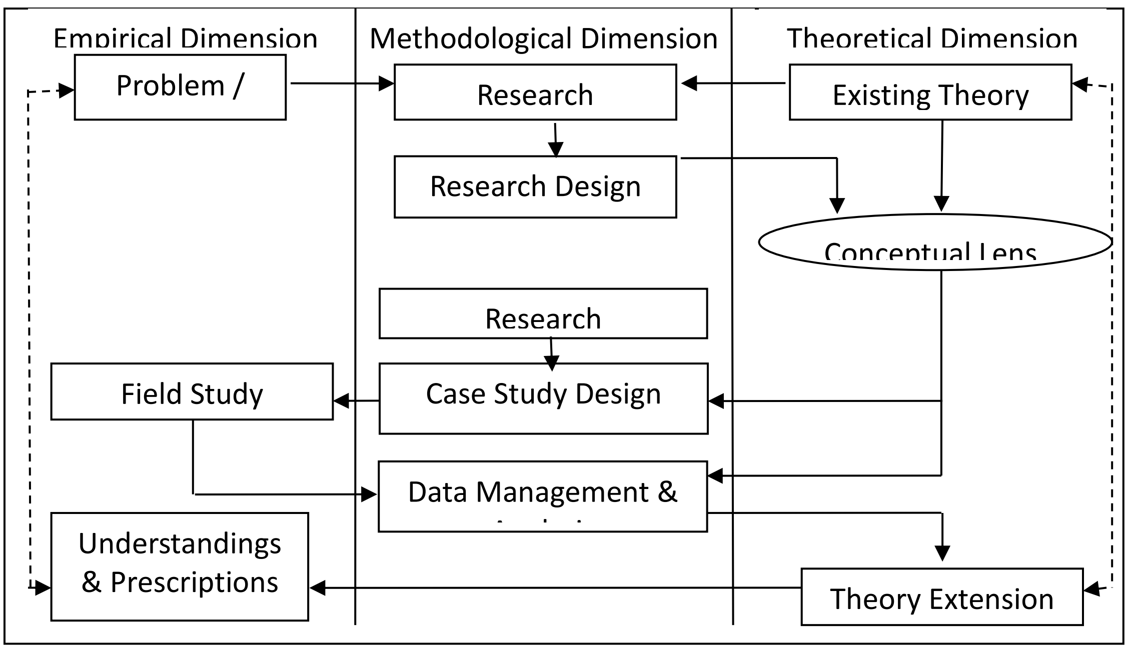


Figure 3.4.1 - Research Process

Within Gas Processing Plant and Refineries in India, the implicit and acquired knowledge understanding Safety Management System could be available with officers and managers who have been working in the organization. We need to collect a thorough understanding of this experienced and knowledge in designing of system and various processes in the Gas Processing Plant and Refineries. As such, to suitably capture and re-use tacit and exclusive knowledge available with plant officers and manager, qualitative research method will be most suitable method for research.

3.5 RESEARCH DESIGN

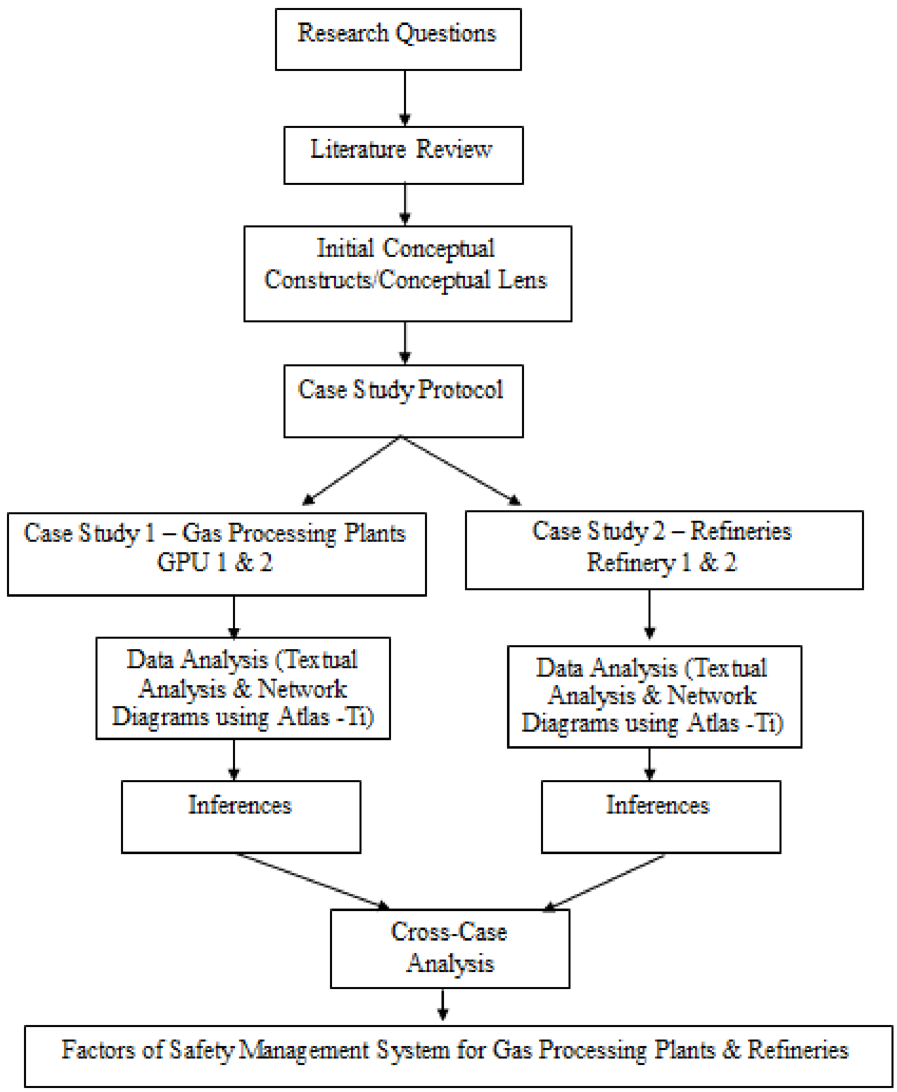
The objectives of this study is to understand what are the existing "Safety Management Systems and Processes" in Gas Processing Plants and Refineries of India and what are the factors in developing good Safety Management System for Gas Processing Plants and Refineries in India? This requires gathering an in-depth understanding on knowledge in formulation and implementation of safety management system & processes in the Gas Processing Plant and Refineries for their effectiveness. Effectiveness of "safety management system and processes" can only be understood through investigation. The Gas Processing Plants and Refinery accidents/incidents during the past years (which are considered as lagging indicators) indicate towards level of effectiveness of Safety Management System.

Identification of such cases calls for prior understanding of likely outcomes. When we take up Multi Case Study, we focus on various reason of the outcomes and we expect that conditions may get replicated from one case to another. We have selected case study method for this research work because, as per the definition of the case study method "*the central tendency among all types of case study, is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result*" (Yin, 2003)

To understand ground reality of successful application of various models and scientific theories, case study research design method is very useful. Though case study research design method, one can focus on particular picked cases. One can test a theory with a picked up unique topic or a particular cases, as identified. Research work needs be thorough, various notes need to be taken systematically and meticulously. Case studies focus on very detailed contextual analysis wok on particular events, conditions and inter-relationships. In cases of "case study research", researchers answer question beginning with word "how" or "why". Only limited numbers of events, limited numbers of conditions and their inter-relationships are focused on, while designing research questions>

This section describes case studies design. The process of conducting case studies is described, primarily. Then design issues like numbers of cases, unit of analysis, selection principles for cases are discussed. Figure 3.5.1 describes the case study design taken up in this research.

Figure 3.5.1 – Case Study Design



Two objectives of this research study was developed and for which appropriate research methodology has been applied to each of the objectives. The research methodology used for Research Objective 1 & 2 is the qualitative research. Gas Processing Plants and Refineries have been chosen for this study.

A Maharatna gas utility company has been chosen for the study on safety management system and processes of Gas Processing Plants having larger share in market of natural gas processing and achieved top gas utility company in India. The Company, a Maharatna Public Sector Undertaking, is having 5 Gas Processing Plants, 2 Petrochemical Processing Plant, more than 11000 KM Natural Gas Pipeline networks and 2050 KM LPG pipeline networks. Company is having major business verticals like Natural Gas Transmission, Petrochemicals, Liquid Hydrocarbons (Gas Processing plant), LPG Transmission, City Gas Distribution, Exploration & Production, Tele communication & Power etc.

Another National Oil Company which enjoys Maharathra status having the entire hydrocarbon value chain – from refining, movement of hydrocarbon and marketing of Oil & Gas products to R&D, E&P, natural gas and petrochemicals marketing, has been selected for the study of safety management system and processes of Refineries. By entering into the Renewable energy and the Nuclear Energy business, this organization grew and evolved itself to become a full-fledged large energy company. This company operates big number of refineries in India adapting to a variety of refining processes and technologies along the way. The processes and technologies, which are in operation in refineries include:

"Atmospheric/Vacuum Distillation; Distillate FCC/Resid FCC; Hydrocracking; Catalytic Reforming, Hydrogen Generation; Delayed Coking; Lube Processing Units; Visbreaking; Merox Treatment; Hydro-Desulphirisation of Kerosene & Gasoil streams; Sulphur recovery; Dewaxing, Wax Hydro finishing; Coke Calcining, etc."

Various business verticals of such large Maharatna companies have unique operation processes in the Gas Processing Plants and Refineries. Hence, "**multi case holistic**

design (Type 3; Yin 2003) of case study research design has been selected for this research work. Multiple-case design has been considered because, the evidence from multiple cases is often more compelling, and the overall study is therefore regarded as being more robust."

3.6 CASE STUDY DESIGN

3.6.1 INTRODUCTION OF CASES FOR OBJECTIVE 1

There are 9 National Gas Processing Plants established in the states of Madhya Pradesh, Maharashtra, Uttar Pradesh and Gujarat in India, which are designed to process Natural Gas. Gas Processing Plant at District Guna, Madhya Pradesh and Gas Processing Plant at Vaghodia, District Vadodara, Gujarat have been chosen for the aforesaid study.

There are 18 National Oil & Gas Refineries established in the states of Bihar, Uttar Pradesh, Gujarat, Haryana, Assam, Tamilnadu, Andra Pradesh, Odisha, West Bengal, Maharashtra and Kerala. Oil Refineries at District Matura, Uttar Pradesh and Panipat, Haryana have been chosen for aforesaid study.

3.6.2 JUSTIFICATION FOR CASES FOR OBJECTIVE 1

The proposed methodology followed shall be a 'Case Study Method' having 'Multiple holistic case design' considering two cases of Gas Processing Plants and Refineries each. Each one of Gas Processing Plant & Refinery having nearly 'NIL' (Good) accident record (with respect to Reportable Accidents, Fatal Accidents, Fires and Explosions) and the other Gas Processing Plant and Refinery each having 'Poor' accident record (with respect to Reportable Accidents, Fatal Accidents, Fires and Explosions) in last five years (2009-2015), have been selected to study existing "Safety Management System". The detail of major accidents occurred at these Gas Processing Plants and Refineries has been obtained from Analysis of Major Incident in Oil & Gas Industry, a document published by Oil Industry Safety Directorate, MOPNG.

3.6.3 CASE STUDY DETAILS FOR OBJECTIVE 1

Unit of Analysis: Plant

Level of Analysis:

1) Unit Level (Senior Management Level)
2) Department level (Head/Dy. Head of Departments)
3) Individual (Supervisory level/Executive level)

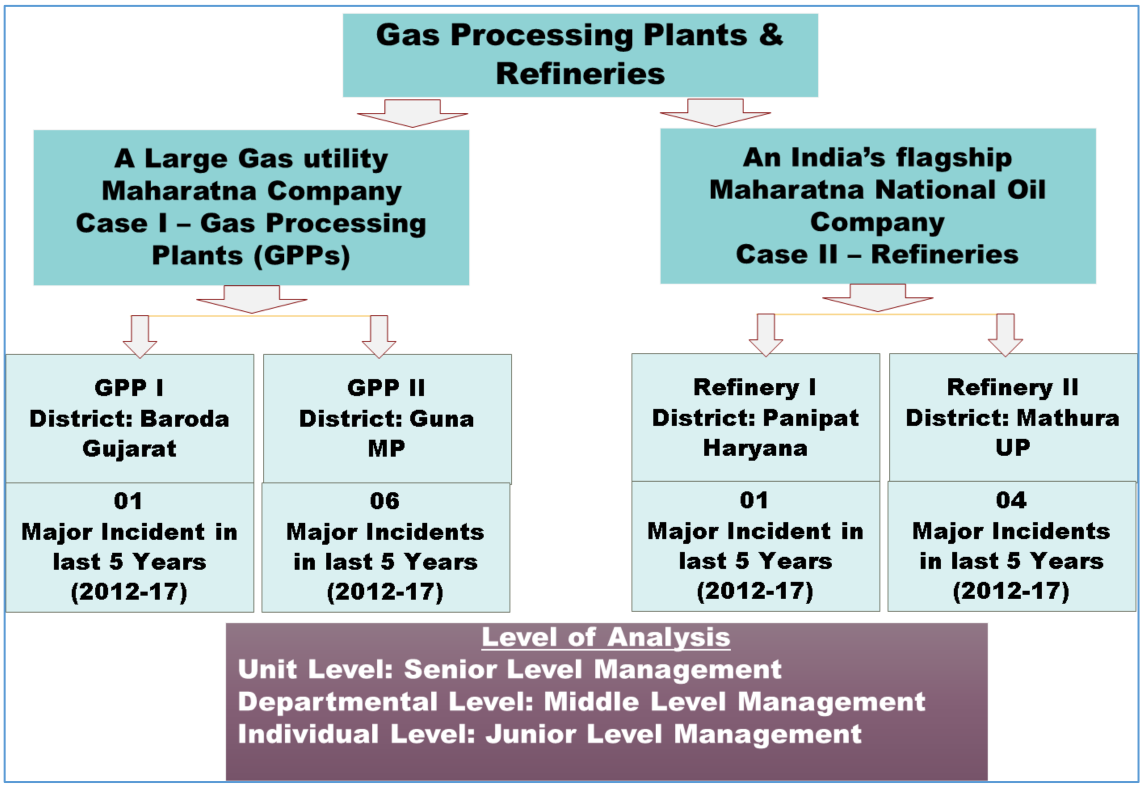


Figure 3.6.1: Details of Case Study for Objective 1

3.6.4 CASE STUDY DETAILS FOR OBJECTIVE 2

Aforesaid two cases on GPPs and refineries have been studied separately and Cross-Case analysis of safety management system and processes in Gas Processing Plants & Refineries are carried out, accordingly. Common and different safety management system, practices and processes are identified for the above two Gas Processing Plants & Refineries of the large Oil & Gas Companies in India. Based on the inputs received from Case 1 & Case 2, suggestive model of safety management system and processes has been developed for the Gas Processing Plants and Refineries in India for objective 2.

Unit of Analysis: Gas Processing Plants and Refineries

Level of Analysis:

1) Safety Expert having experience more than 25 years in Gas Processing Plants and Refineries
2) Safety Expert having experience more than 15 years in Gas Processing Plants and Refineries
3) Safety Expert having experience more than 8 years in Gas Processing Plants and Refineries
4) Interview with Licenser/Consultant and Human Resource specialist having experience more than 15 years in Gas Processing Plants/Refineries.

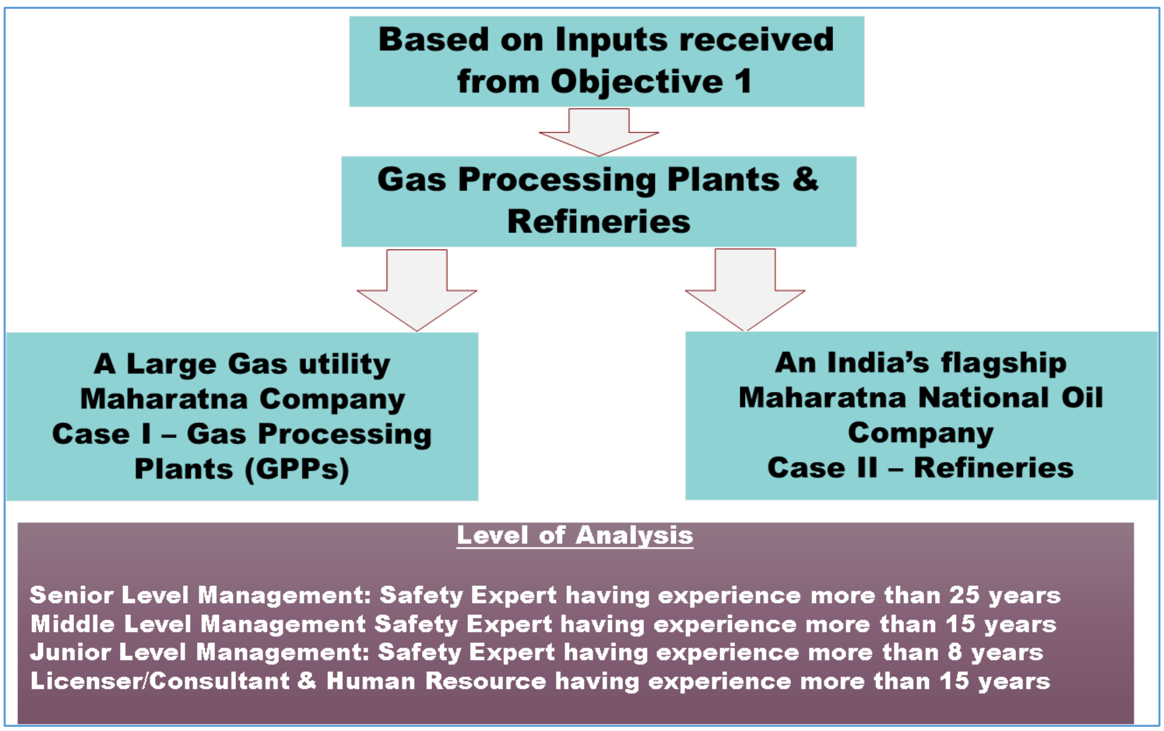


Figure 3.6.2: Case Study Details for Objective 2

3.7 DATA COLLECTION

Data collected in the process was analysed and interpreted, which is "immersion in the details and specifics of the data to discover important categories, dimensions, and interrelationships; exploring genuinely open questions rather than testing theoretically derived hypotheses" (Patton, 1990). Qualitative data is "detailed, thick description, inquiry in depth, direct quotations capturing people's personal perspectives and experiences" (Patton, 1990).

"Case studies provide a special way of collecting, organizing, and analyzing data together bringing in comprehensive, systematic, and in-depth information about each case of interest. The case study method allows people being interviewed to describe experiences in their own language, rather than the researchers'. Case study research involves gathering evidence from a variety of sources, documents, archival records, questionnaire, interviews, observations, and physical artifacts" (Eisenhardt, 1989, Yin, 2003). The validity of research findings are ensured through triangulation of data collected from various sources and in-depth study of a phenomenon from different angles.

Site visits for the case studies were performed as part of primary activities in the data collection stage and collecting data as needed. The empirical investigation included collecting data from the GPPs and Refineries of Oil & Gas Companies in India.

Data at the gas utility company was obtained from various sources i.e participant observation, interviews, informal discussions and archival documents. "The observations focused on the process elements of context, actors and actions" (Pettigrew, 1997). Comprehensive field notes were made by researcher and noted down the communications taking place among the fire and safety manager at the plants, whenever could be possible.

The data was collected from the Operation, Maintenance and Fire Safety Managers of Oil & Gas Companies using "**case study protocol".** A case study protocol is a guide document that consists the questionnaire (instrument) for data collection as well as the general procedures/rules to be followed in using the protocol. The maintenance, operation and fire safety officers posted at different locations where interviewed by researcher at facility or at head office. Keeping in mind "unit of analysis" and "level of analysis" 14 officers were identified, who were involved in O&M activities and Fire Safety activities. Interviews were setup with these officials covering both the case studies i.e. Case Study 1 & Case Study 2. "Case Study Protocol" was designed to collect data and to organize "semi structured interviews" with safety experts for objective 2.

During data collection stage, Construct validity was checked using multiple sources of evidence (document analysis) and reliability was ensured by using case study protocol (Yin, 2003). A copy of the Data Collection Protocol used for interview is attached in Appendix I & II.

Before initiating the interview, it was apprised to the interviewee person that the case study material and the interview data will be used for research work, to study safety management system and processes. A brief introduction was also given by the interviewee person about this case study research based on the framework given above.

The interviews were conducted at three levels. The three/four levels are as given under:-

For Objective 1

1) Interview with Senior Management (Operation/Maintenance Heads in Unit Level)
2) Interview with Middle Management (Departmental Heads at Unit Level)

3) Interview with Junior Management (Engineers/Supervisors at Unit Level)

For Objective 2

1) Interview with Senior Management having experience more than 25 years in Gas Processing Plants/Refineries in field of Safety

2) Interview with Senior Management having experience more than 15 years in Gas Processing Plants/Refineries in field of Safety
3) Interview with Senior Management having experience more than 08 years in Gas Processing Plants/Refineries in field of Safety
4) Interview with Licenser/Consultant & Human Resource having experience more than 15 years in Gas Processing Plants/Refineries.

Those interviews contained generally 15-40 minutes of discussions. In order to properly utilize inputs of interviews for research work, we recorded the discussions and later transcribed complete dialogues. After typing interview dialogues, the matter was once again made available to respective interviewee for his/her consent. Table 3 summarized various steps involved in collection of data for all cases.

Primarily Safety, Operation and Maintenance personnel were interviewed for in-depth understanding of Safety Management System and Processes. "Whenever it was felt that no additional data and codes are being found on subject matter, decision was taken to stop further interviews at that point. In original treatise on grounded theory", Glaser and Strauss (1967: p. 61) defined saturation in these terms.

"The criterion for judging when to stop sampling the different groups pertinent to a category is the category's theoretical saturation. Saturation means that no additional data are being found whereby the sociologist can develop properties of the category. As he sees similar instances over and over again, the researcher becomes empirically confident that a category is saturated. He goes out of his way to look for groups that stretch diversity of data as far as possible, just to make certain that saturation is based on the widest possible range of data on the category."

Here, "the decision to be made relates to further sampling, and the determinant of adequate sampling has to do with the degree of development of a theoretical category in the process of analysis. Saturation is therefore closely related to the notion of theoretical sampling—the idea that sampling is guided by 'the necessary similarities and contrasts required by the emerging theory' (Dey 1999: p. 30)—and causes the researcher to 'combine sampling, data collection and data analysis, rather than treating them as separate stages in a linear process' (Bryman 2012: p. 18)."

Table 3.7.1- Main Steps in Data Collection – Objective 1

Steps in data collection	**GPU-1 (Case Study 1)**	**GPU-2 (Case Study 2)**
Development of Case Study Protocol (CSP), Review and final CSP development	**June 2015 - July 2017**	
Data Collection Survey/Interviews	Feb-June 2016 July-August 2017	Feb-June 2016 July-August 2017
Site visits for field observations	February 2017	August 2016
Additional data collection	July-August 2017	July-August 2017
Total Number of interviews	04	04
Steps in data collection	**Refinery - 1 (Case Study 2)**	**Refinery -2 (Case Study 2)**
Development of Case Study Protocol (CSP), Review and final CSP development	**June 2017 – April 2018**	
Data Collection Survey/Interviews	Jan-April 2018	Jan-April 2018
Site visits for field observations	Jan-April 2018	Jan-April 2018
Additional data collection	Jan-April 2018	Jan-April 2018
Total Number of interviews	03	03

Table 3.7.2 - Main Steps in Data Collection – Objective 2

Steps in data collection	**Gas Processing Plants & Refineries**
Development of Case Study Protocol (CSP), Review and final CSP development	**March 2018**
Data Collection Survey/Interviews	March-June 2018
Additional data collection	March-June 2018
Total Number of interviews	10

3.8 DATA ANALYSIS

The objective of qualitative examination is to generate findings through analysis, its interpretation and presentation of findings. The challenges in data analysis is to "make sense of massive amount of data, reduce the volume of information, identify significant patterns, and construct a framework for communicating the essence of what the data reveals" (Patton, 1990). A modified form of "grounded theory approach" has been used for analyzing the data in this research as this approach is based on "the researcher's interpretations and description of phenomena based on the actors' subjective descriptions and interpretations of their experiences in a context" (Locke, 2001; Charmaz, 2006).

Data analysis is aimed to identify describing (i) Planning & Execution of Safety Management System Processes (ii) comprehensive Safety Management Model applicable to Indian GPUs and Refineries. To main parts of data analysis are "within-case analysis" and "cross case analysis". "Within case analysis" entailed becoming intimately familiar with each case individually and documenting it thoroughly. In cross-case analysis, similarities and differences across cases were explored. "Within-case analysis involved organizing the data of specific cases for in-depth study and helped to manage the staggering volume of data (Eisenhardt, 1989)". Once the data collection and analysis for each case was completed by researcher, the search for cross-case patterns was done. "Patterns in qualitative data can be represented as dimensions, categories, classification of schemes, and themes" (Patton, 1990). For categories to look for within-case similarities and between-case differences, conceptual lens construct were used as the basis.

“Textual Analysis” and cross case synthesis Data Analysis was done for the data analysis. Textual analysis was conducted by using of Atlas TI software and network diagrams were developed with the necessary quotation and frequency analysis.

“The data analysis using grounded theory is a highly iterative process involving moving between interview data, existing theory, and observation data” (Charmaz, 2006).

Following three steps were used iteratively for conducting data analysis:

1. “Open Coding
2. Focused/Selective Coding
3. Identifying patterns of relationship among conceptual categories”

The first two steps provided understanding on (i) Planning & Execution of Safety Management System Processes (ii) Safety in Operation & Maintenance in Gas Processing Plants and Refineries by developing codes, categories and concepts of safety processes being followed in the plant. The last step helped in identifying the factors contributing to the selection of safety processes and their impact in safety management system. Details of these activities are as given under:-

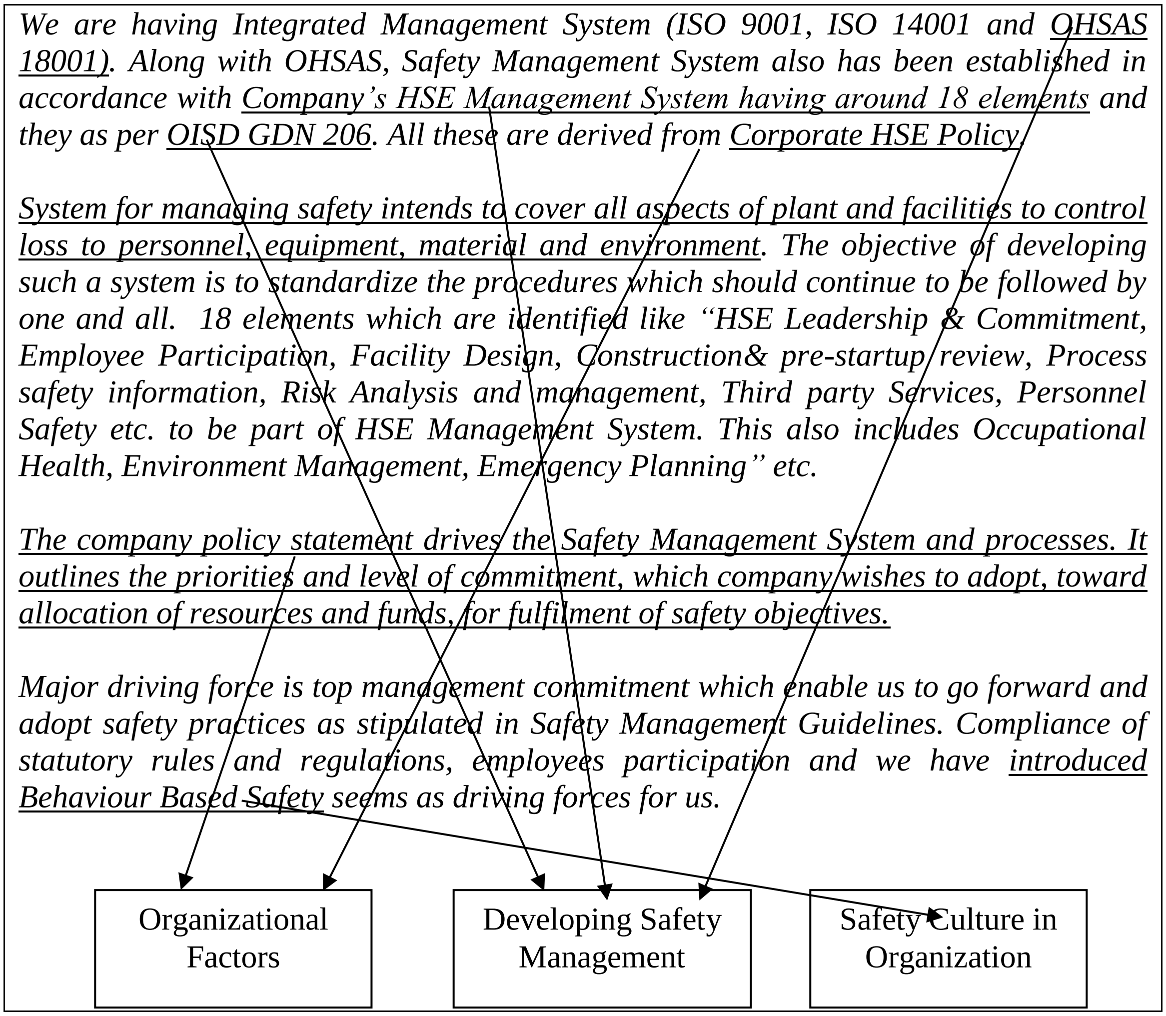
Step I: Open Coding

Input data was designated, categorized and combined to know main concepts and find the relevant constructs. Part of the text which are sentences or paragraphs (Strauss and Corbin, 1990) describing (i) Planning & Execution of Safety Management System Processes (ii) Safety in Operation & Maintenance, assigned “labels for easy retrieval and categorization” (Miles and Huberman, 1994) “using open code technique” (Strauss and Corbin, 1990; Charmaz, 2006).

Open Coding is a method where “the investigator identifies potential themes by pulling together real examples from the text” (Ryan and Bernard, 2000) which suggests that the codes are discovered from the empirical data. New codes are created as a new evidence (for example issues, themes) which emerges from data. The open coding is used to “investigate a new phenomenon, and focus of research is on the emergence of theoretical categories from empirical evidence” (Strauss and Corbin, 1990; Charmaz, 2006).

Figure 3.8.1 below demonstrates how the open coding was conducted, which is based on a statement obtained from interview. In the example statement, the words “OHSAS 18001”, “gas utility company’s HSE Management System”, “OISD GDN 206” illustrate the Model of Safety Management System (explains initial conceptual construct Development of Safety Management), therefore, in open coding step these were marked as code. Similarly, phrase “Corporate HSE Policy” illustrates about Leadership and Commitment (explains initial conceptual construct Organizational factors influencing safety) and therefore marked as code. Phrase “Introduction of Behaviour Based Safety” illustrates the Sustainable Safety Performance i.e., it explains Safety Culture in Organization, and accordingly marked as code.

Figure 3.8.1 – Examples of Codes

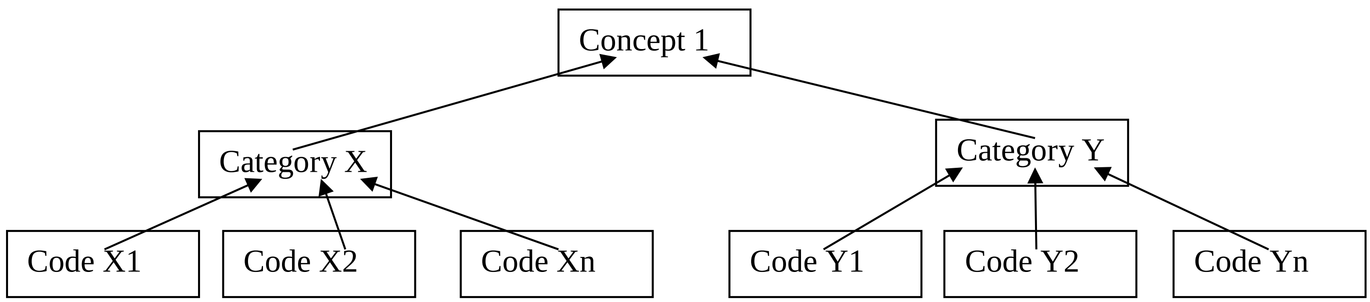


Qualitative Analysis software Atlas-Ti used for coding of interview scripts. "This software facilitated the analysis process by helping with coding, linking codes, and text segments, creating memos, searching, editing and reorganizing, and for visual display of data and findings" (Miles and Huberman, 1994; Weitzman, 2000; Creswell, 2007).

Step II: Focused Coding / Selective Coding

"In focused/ selective coding, similar codes, codes with some common attributes were merged to create conceptual categories and abstractions from the empirical data" (Strauss and Corbin, 1990). "This consolidation of cases made possible the reduction of number of units the researcher is working with (Strauss and Corbin, 1990) and clarified the main themes emerging from the data. Codes were grouped into categories using a bottom up approach" as shown in the Fig. 3.8.2 given below.

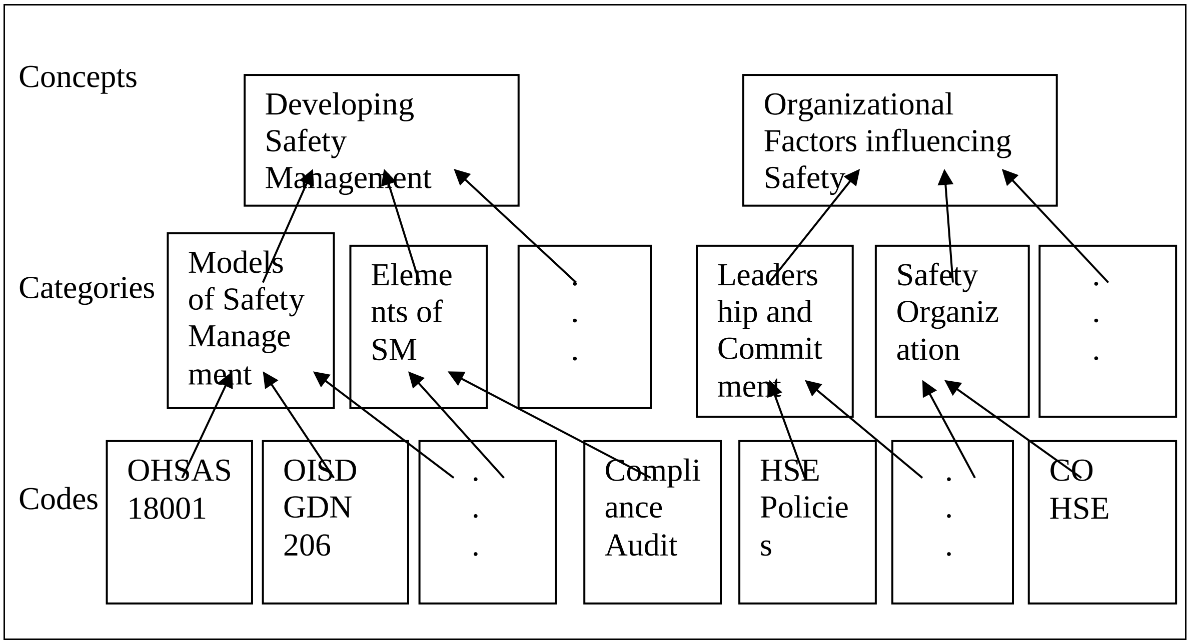
Figure 3.8.2 – Codes, Categories, and Concepts



Codes illustrating (i) Operation & Maintenance, (ii) Process Safety Information, (iii) Personnel Safety, (iv) Occupational Health as found during the processing of open coding, where further consolidated and brought out to broader categories. Those categories were further classified and named as concepts/themes being "basic unit of analysis" in the "grounded theory".

Initial Conceptual Constructs identified as related to safety management system and processes aided as basis of finding concepts. Reports illustrating these initial conceptual constructs were coded first. Thereafter these codes were consolidated into categories: each category represented the factors which are related to safety management system and its processes in Gas Processing Plants. Finally, each category was linked to the categories of Initial Conceptual Constructs. In a category which could not be associated with the Initial Conceptual Constructs, was identified a new factor (a new concept). Figure shows this categorization and linking process in detail.

Figure 3.8.3 – Categorization and linking of codes, categories & concepts



All the interview data was labelled as codes categories and concepts by means of open and focused coding. Inter relationship between codes and categories could be called as "compositional" by nature which meant that identification of relationship between codes, categories and concepts was done before defining composition of concept or category through this relationship. The relationships were generally in the form of 'is part of', 'is a', 'is associated with'.

Step III: Identifying patterns of relationships among conceptual categories

Under this step causal and associate relationships were identified between codes, categories and concepts. Further, by developing appropriate codes utilizing "Atlas Ti" software, various management processes were identified based on input received during interviews.

Figure-3.8.4 Causal relationships identified from interview statements

We are having Integrated Management System (ISO 9001, ISO 14001 and OHSAS 18001). Along with OHSAS, Safety Management System also has been established in accordance with Company's HSE Management System having around 18 elements and they as per OISD GDN 206. All these are derived from Corporate HSE Policy.

System for managing safety intends to cover all aspects of plant and facilities to control loss to personnel, equipment, material and environment. The objective of developing such a system is to standardize the procedures which should continue to be followed by one and all. 18 elements which are identified like "HSE Leadership & Commitment, Employee Participation, Facility Design, Construction & pre-startup review, Process safety information, Risk Analysis and management, Third party Services, Personnel Safet"y etc. to be part of HSE Management System. This also includes Occupational Health, Environment Management, Emergency Planning etc.

The company policy statement drives the Safety Management System and processes. It outlines the priorities and level of commitment, which company wishes to adopt, toward allocation of resources and funds, for fulfilment of safety objectives.

Major driving force is Top Management Commitment which enable us to go forward and adopt safety practices as stipulated in Safety Management Guidelines. Compliance of statutory rules and regulations, employees participation and we have introduced Behaviour Based Safety seems as driving forces for us.

is part of in association with

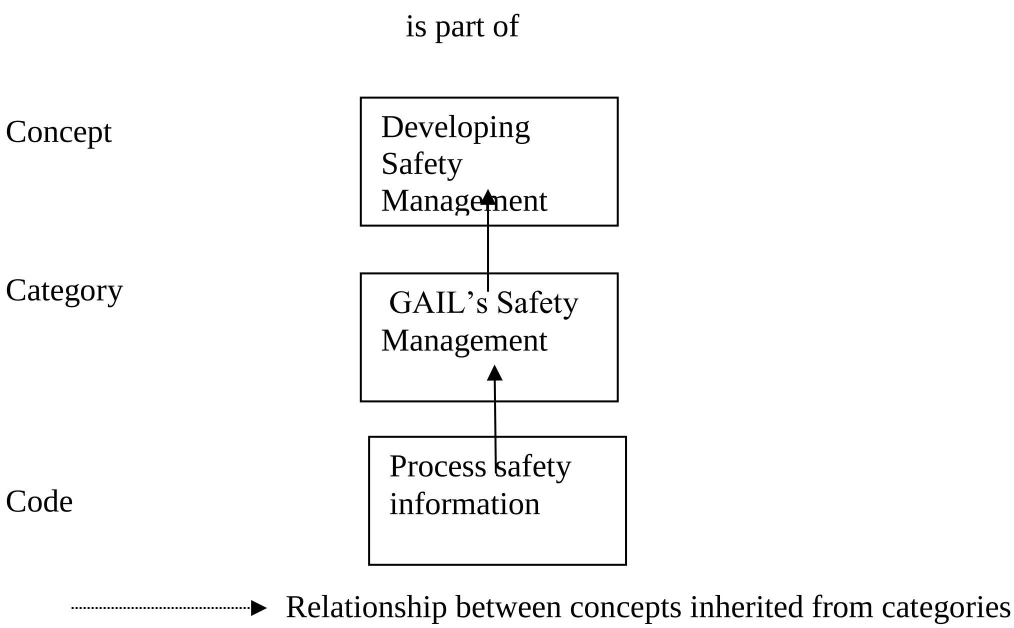
Figure 3.8.4 shows how causal relationships were identified from the interpretation of interview statements. As shown above "18 elements" are specific aspects being adopted in safety management that are part of "Company's HSE Management System". In order to achieve company's safety objective/policy, "Employees Participation", "Process Safety Information" etc are aspects associated with 18 elements. Similarly, "the company policy statement drives the Safety Management System and processes. It outlines the priorities and level of commitment" of "Top Management" in the Gas Processing Plant. Similarly, 'Behaviour Based Safety' drive 'is associated with company's HSE Management System. Accordingly, these codes were linked through Atlas-Ti software by "is part of" and "is association of" relations, as shown in figure.

The causal relationship "is part of" between the codes is inherited in turn by respective categories and codes as shown in figure (Fig.7) below.

Figure 3.8.5- Relationships between concepts/categories inherited from codes

"We are having Integrated Management System (ISO 9001, ISO 14001 and OHSAS 18001). Along with OHSAS, Safety Management System also has been established in accordance with Entity's HSE Management System having around 18 elements and they as per OISD GDN 206. All these are derived from Corporate HSE Policy.

System for managing safety intends to cover all aspects of plant and facilities to control loss to personnel, equipment, material and environment. The objective of developing such a system is to standardize the procedures which should continue to be followed by one and all. 18 elements which are identified like HSE Leadership & Commitment, Employee Participation, Facility Design, Construction & pre-startup review, Process safety information, Risk Analysis and management, Third party Services, Personnel Safety etc"



CHAPTER 4.0: ANALYSIS AND INTERPRETATION OF THE DATA

4.1 INITIAL CONCEPTUAL LENS/CONSTRUCTS FOR THE STUDY – OBJECTIVE 1

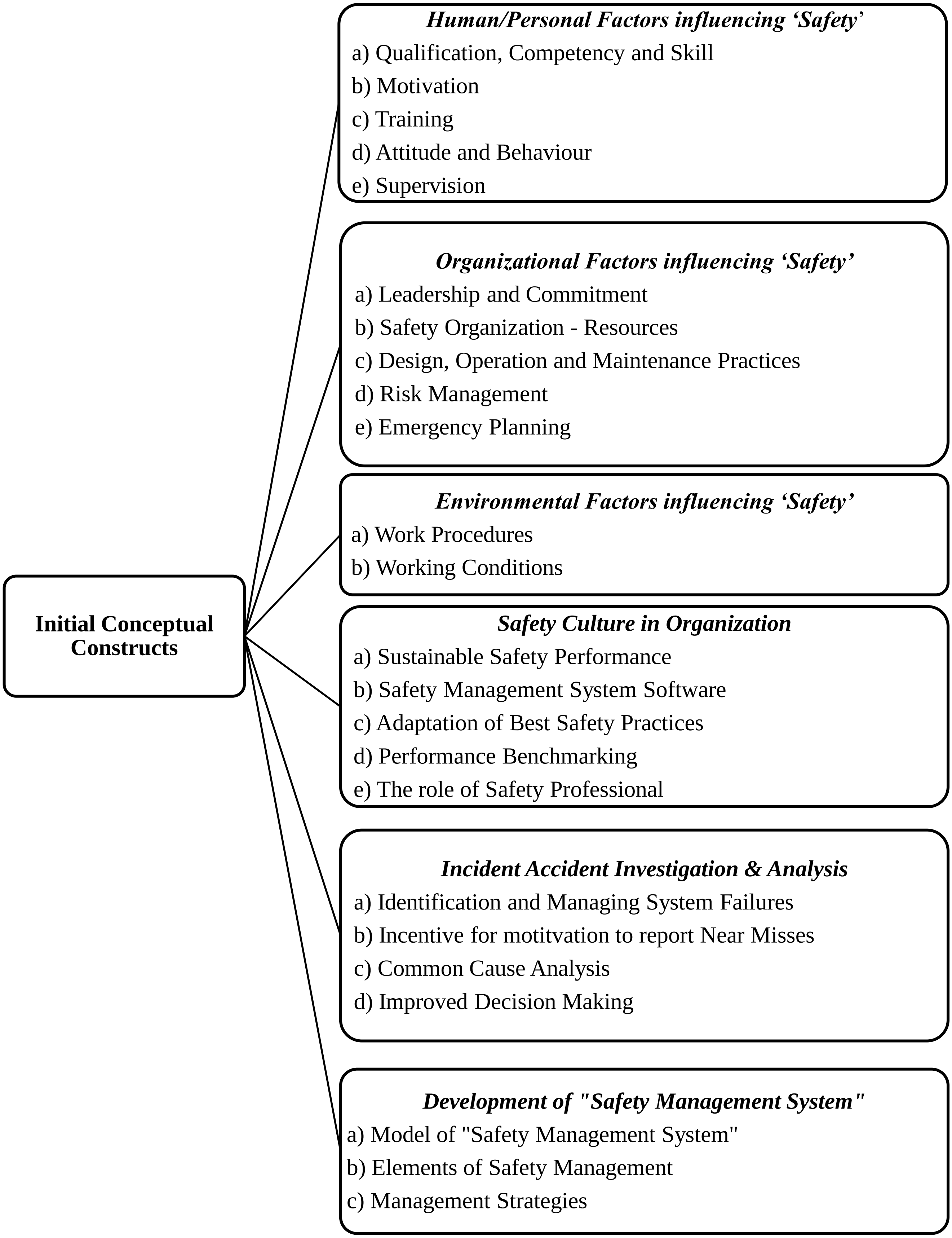
“A conceptual lens represents the researcher’s synthesis of literature on how to explain a phenomenon. It gives out the actions required in the course of the study given his previous knowledge of other researchers’ point of views and his observations on the subject of research. In other words, the initial conceptual lens is the researcher understanding of how the particular variables in his study connect with each other. Thus, it identifies the variables required in the research investigation. Researcher uses this initial conceptual lens for the study which provides overall orientation lens for the study of questions of gender, class and race. This lens become an advocacy perspective that shapes the type of questions asked, informs how data are collected and analysed.”

Based on literature review, researcher has formulated six conceptual constructs model for this research which is Human/Personal Factors influencing ‘Safety’, Organizational Factors influencing ‘Safety’, Environmental Factors influencing ‘Safety’, Safety Culture in Organization, Incident Accident Investigation & Analysis and Developing Safety Management System. Each one of these constructs can be further divided into its sub-constructs and/or the attributes of interest, as given under:-

Table: 4.1.1

SN	Initial Conceptual Constructs	Sub Constructs
1.	Human/Personal Factors influencing 'Safety' (Function 1: F1)	Qualification, Competency and Skill
		Motivation
		Training
		Attitude and Behaviour
		Supervision
2.	Organizational Factors influencing 'Safety' (Function 2: F2)	Leadership and Commitment
		Safety Organization – Resources
		Design, Operation and Maintenance Practices
		Risk Management
		Emergency Planning
3.	Environmental Factors influencing 'Safety' (Function 3: F3)	Work Procedures
		Working Conditions
4.	Safety Culture in Organization (Function 4: F4)	Sustainable Safety Performance
		Safety Management System Software
		Adaptation of Best Safety Practices
		Performance Benchmarking
		The role of Safety Professional
5.	Incident Accident Investigation and Analysis (Function 5: F5)	Identification and managing system failures
		Incentive for motivation to report Near misses
		Common Cause Analysis
		Improved Decision making
6.	Development Safety Management System (Function 6: F6)	Models of Safety Management
		Elements of Safety Management
		Management Strategies

Figure 4.1.1



Initial Conceptual Constructs
Human/Personal Factors influencing 'Safety'
a) Qualification, Competency and Skill
b) Motivation
c) Training
d) Attitude and Behaviour
e) Supervision
Organizational Factors influencing 'Safety'
a) Leadership and Commitment
b) Safety Organization - Resources
c) Design, Operation and Maintenance Practices
d) Risk Management
e) Emergency Planning
Environmental Factors influencing 'Safety'
a) Work Procedures
b) Working Conditions
Safety Culture in Organization
a) Sustainable Safety Performance
b) Safety Management System Software
c) Adaptation of Best Safety Practices
d) Performance Benchmarking
e) The role of Safety Professional
Incident Accident Investigation & Analysis
a) Identification and Managing System Failures
b) Incentive for motitvation to report Near Misses
c) Common Cause Analysis
d) Improved Decision Making
Development of "Safety Management System"
a) Model of "Safety Management System"
b) Elements of Safety Management
c) Management Strategies

4.2 CASE STUDY PROTOCOL FOR OBJECTIVE 1

A Case Study Protocol for collection of data for Objective and Research Question 1 i.e How National Gas Processing Plants and Refineries plan and execute their Safety Management System and related processes, to ensure safety in Operation and Maintenance? A Case Study Approach – Data Collection Protocol for Study of Existing Safety Management System of Gas Processing Plants and Refineries is attached as Appendix I.

There were 20 questions, primarily covering the aspects of Objective 1, which deals with planning and execution of existing Safety Management System in Gas Processing Plants at District Vaghodia & Guna and Refineries at District Panipat and Mathura respectively.

Table 4.2.1

SN	Initial Conceptual Constructs	Addressing Questions
1.	Human/Personal Factors influencing ‘Safety’ (Function 1: F1)	4, 9, 11, 12, 20
2.	Organizational Factors influencing ‘Safety’ (Function 2: F2)	3, 4, 6, 7, 8, 14, 20
3.	Environmental Factors influencing ‘Safety’ (Function 3: F3)	4, 10, 14, 20
4.	Safety Culture in Organization (Function 4: F4)	4, 6, 7, 8, 13
5.	Incident Accident Investigation and Analysis (Function 5: F5)	11, 15, 16, 17
6.	Development Safety Management System (Function 6: F6)	2, 4,5, 8, 14, 18, 19

4.3 CASE STUDY : GAS PROCESSING PLANT 1

4.3.1 INTRODUCTION

Gas Processing Plant of Gas Utility Company situated at Vaghodia, is located at GIDC Industrial Estate, Vaghodia, District: Vadodara, Gujarat. The installation is receiving Natural Gas by Cross Country Pipelines and is processing Natural Gas to recover Liquefied Petroleum Gas (LPG) and storing and handling petroleum products and NG, in a large volume. The installation is registered under the Factory Act 1948. The installation is also covered under statutes like Petroleum and Explosive Safety Organization (PESO), State Pollution Control Board etc. The installation was started in year 1993. The installation is manned round the clock, deploying workers at about 200 including contract workers. The recovery plant is designed to process natural gas from Cross Country Pipeline and designed to produce LPG by processing 2.6 MMSCMD (Million Metric Standard Cubic Meters per Day). The gas processing plant having the storages of LPG, Naptha, Ethyl Mercaptane and High Speed Diesel. During the year 2009-2015, no major or minor incidents reported to Oil Industry Safety Directorate (OISD).

4.3.2 DATA COLLECTION

Semi structured interviews were conducted with following operation, maintenance and fire safety plant personnel in the safety related area using case study protocol:-

Table 4.3.1 - List of interviewees of Case Study-1 (Gas Processing Plant -1)

Level of Analysis	Designation	Date of Interview
Level 1 – Senior Management, Unit Level	General Manager (Operations &Maintenance)	11.08.2017
Level 2 – Middle Management, HODs of Operation/Maintenance/ FS	Chief Manager (Fire & Safety)	08.08.2017
Level 3 – Junior Management Level, Engineers/Supervisors	Senior Manager (Fire & Safety) Manager (F&S)	08.08.2017

The case analysis results are exhibited in the form of “qualitative associative networks” (See Appendix III). “Associative networks have nodes linked to each other by association and allows for fuzzy, intuitive and, subconscious relations between concepts to be presented visually”. Representation of associative networks have been done using “boxes” and “arrows”, with the boxes containing the concepts and the arrows representing the relationships among them. The arrows can be “unidirectional” and “bi-directional”. “Relationships can include causality, association, choices, time” (Ryan and Bemard, 2000). The qualitative associative networks created for this case study are shown in Appendix III.

4.3.3 DESCRIPTION OF EXISTING SAFETY MANAGEMENT SYSTEM

Gas Processing Plant is having “Integrated Management System” (ISO 9001, ISO 14001 and OHSAS 18001). Along with OHSAS, Safety Management System also has been established in accordance with GAIL’s HSE Management System having 18 elements and as per OISD GDN 206. The objective of developing such a system is to standardize the procedures which should continue to be followed by one and all. 18 elements which are identified like HSE Leadership & Commitment, Employee Participation, Facility Design, Construction& pre-startup review, Process safety information, Risk Analysis and management, Third party Services, Personnel Safety etc. to be part of HSE Management System. This also includes Occupational Health, Environment Management, Emergency Planning etc.

Corporate HSE Policy of the Gas Utility Company is signed by Chairman and Managing Director having commitment to conduct business with a robust and “integrated Health, Safety and Environment Management System”. Corporate HSE Policy is the apex document for them which guide them in development of Safety Management System at plant level. This document clearly defined the approach for development of Safety Management System, which includes:

- Regulatory Requirements
- Organizational aspects like system, resources, guidelines etc.
- Procedure to bring change in working environment or processes due to introduction of new system, or new technologies etc.
- Individual aspects on development of competency, skills, training etc.

HSE Group at Corporate Level, formulates HSE Policies and guidelines in consultation with various Management levels and subsequent approval from CEO of the company. Safety organization is also in place at Plant/Installation Level as far as GPU is concerned. The responsibility related to Safety Management lies with Occupier and Factory Manager. Safety Department is manned with qualified and experienced executives for assistance.

Human/individual empowerment is an essential part of safe execution of work. This can happen only through involving people i.e all employees who so ever work inside the complex. Responsibilities fall with the supervisor to provide appropriate level of competency in terms of qualification, training, knowledge and experience to all employees/workers. Empowerment to observe, report and stop any unsafe activity at site has been given to employees including contract workers. Participation of employees in plant safety committees and safety talks etc. is encouraged.

Operation and Maintenance Philosophy based on reputed and International Standards is in place. Risk Analysis is being done on regular basis. Standard Operating Procedures and maintenance work instructions are in place. Work Permit System is also there. In case of any critical job, Job Safety Analysis is conducted before starting of job. Procedure for strict Supervision is in place by senior officials and fire safety personnel, in case of critical jobs.

Employees are encouraged through token gifts and incentives for identifying potential failure scenarios. Investigation of the incidents is done and data is collected and analysed. Site visit and recording of statement of witnesses is done. In order to prevent reoccurrences, recommendations obtained during investigation of incident are disseminated amongst employees.

Top Management Leadership and Commitment is the main driving force for employees at GPU. Compliance to Statutory Rules and Regulations and going beyond, employees' participation in safety management and implementation of BBS are also driving forces in execution of safety processes. Employees are empowered working at site on 'Safety First' principle. Safety is always considered utmost priority of Plant. The challenges pertaining to plant are multiple Statutory Rules, Regulations and Statutory Authorities and reporting to various authorities for legal compliances. Meeting those requirements of various guidelines and procedures within the organization is found to be concerned for Gas Processing Plant.

Critical observations in the above process of data analysis are summarized in Table 5, as given below:

Table 4.3.2: Open Codes- Case Study 1: GPU 1

SN	Initial Conceptual Constructs	Open Codes
1.	Human/Personal Factors influencing 'Safety' (Function 1: F1)	Qualification, competency and experience of contractor workers/employees, Manning safety department with qualified professionals, Human Empowerment, Empower to observe, report and stop, Employees participation in safety, Safety suggestion scheme, Token gift and incentives, Reinforce safe behavior of employees, Nomination of BBS observers, Safety/pep talk, In house training facilities, Refreshing the knowledge of people, Regular trainings, Strict supervision, Supervision by F&S and Senior Officials, Responsibility to provided appropriate

		level of competency etc.
2.	Organizational Factors influencing 'Safety' (Function 2: F2)	Clearly defined approach, Corporate HSE Policy, Commitment to conduct business with HSEMS, Corporate Policy approved by CEO, Keen to address safety issues, Indent to loss control, Formulate safety policies and guidelines, Outline the priories and level of commitment, Allocation of resources and funds, HSE group at Corporate, Monitor successful implementation of SMS, Safety organization at unit level, Annual planner/schedule, Assigned time lines for maintenance activities, Pre planning and prioritizing activities, Standardization of procedures, Maintenance work instructions, Automations in plant, Conducting Hazop, Organizing QRA, Conducting job safety analysis, Automatic fire detection, Smoke detections, Ensure availability of firefighting systems, Mock drills, Emergency plans etc.
3.	Environmental Factors influencing 'Safety' (Function 3: F3)	Hazard information, Display of SOPs, Display of MSDS, SOPs, Change in working environment and process, Conducting job safety analysis, Work permit system, Ensure safe work completion, Understand hazards associated with particular activities, Safety/pep talk before the job, Risk at acceptable level, Issuer, receiver and safety meet to evaluate risk etc.
4.	Safety Culture in Organization (Function 4: F4)	Top management leadership, Leadership and commitment at all level, Taking safety accountabilities and responsibilities, Implementation of BBS Concept, Operation &

		Maintenance philosophy based on reputed National and International Standards, Automations in plant, Ensure implementation of SMS guidelines and procedures, Assist Occupier and factory manager, Measuring safety performance through HSE Score, Review performance periodically, Monitoring milestone against activity, Performance review by OIC on monthly etc.
5.	Incident Accident Investigation and Analysis (Function 5: F5)	Identify, correct and report unsafe act and conditions, Safety observation and near miss reporting system, Online system, Investigation of incidents, maintaining record in SAP, Incentive for reporting near miss, Token gift and incentives, sharing of near misses, Investigation of incidents, Multi-disciplinary group team to investigate, Identify root cause of incident, Prevent re-occurrences, Compliance of recommendations in time bound manner, Reinforce safety behavior of employees, Dissemination of incident learning etc.
6.	Development of Safety Management System (Function 6: F6)	OISD GDN 206, OHSAS 18001, Organiation's Safety Management System, HSE Leadership & Commitment, Employee Participation, Facility Design, Construction & pre-startup review, Process safety information, Risk Analysis and management, Third party Services, Personnel Safety, Control of Defeat and Reliability of Critical system and Devices, Work Permit System, Operation & Maintenance Procedures, Inspection & Maintenance, Management of

		Change, Training, Incident Investigation & Analysis, Occupational Health, Environment Management, Emergency Planning and Response, Compliance Audit, Zero accident and zero injury, Adopt high level of safety, etc.
		Multiple statutory rules, regulations and authorities, Committed to ensure compliance of regulations, Occupier, Factory manager, Local safety policy following factory act and rules, Regulatory requirements associated in operations and maintenance etc.

Table 4.3.3: Critical Observations on Data Analysis- Case Study 1: GPP 1

Initial Conceptual Constructs	Sub Constructs	Categories based on empirical data	Focused codes developed from empirical data	Observation on Data Analysis
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills (2)	Human factors	Qualification, competency and skill of employees and workers Fire & Safety Department is manned with qualified and experienced executives.	This method exists in the plant
	Motivation (5)		Human and individual empowerment Empowerment to observe, report and stop any unsafe activity. Employees' participation in	This method exists in the plant

			safety Safety suggestion scheme	
	Training (4)		In-house training facilities Refreshing the knowledge of people Regular trainings on various HSE aspects. Training through third party	This method exists in the plant
	Attitude and Behaviour (2)		Reinforce safe behivour of employees Nomination for BBS observer training	This method exists in the plant
	Supervision (3)		Strict supervision during activity. Strict supervision by seniors and Fire Safety personnel. Responsibility to provide appropriate level of competent resource.	This method exists in the plant
(Function 2) Organizational Factors influencing Safety	Leadership and Commitment (8)	Organizational Factors	Clearly defined approach. Corporate safety policy Commitment to conduct business	This method exists in the plant

			with HSEMS. Corporate safety policy approved by CEO. Keen to address safety issues. Outline the priorities and level of commitment. Formulates safety policy and guidelines. Intent to loss control	
	Safety Organization & Resources (4)		Allocation of resources and funds HSE group at Corporate Monitor successful implementation of SMS Safety organization at Unit Level	This method exists in the plant
	Design, Operation and Maintenance Practices (6)		Annual planner/schedule Assigned timelines for maintenance activity. Automation of plants	This method exists in the plant

			Maintenance work instructions Pre-planning and prioritizing activities Standardization of procedures	
	Risk Analysis and Management (4)		Conducting HAZOP Conducting Job Safety Analysis Organizing QRA Regular Risk Analysis	This method exists in the plant
	Emergency Planning and Response (5)		Automatic fire detection Ensure availability of fire-fighting system Smoke detection Mock drills and emergency plans Ensure availability of firefighting system	This method exists in the plant
(Function 3) Environmental Factors influencing Safety	Work Procedures (5)	Environmental Factors	Standard operating procedures Change in work environment and processes. Conducting job safety analysis	This method exists in the plant

			Ensure safe work completion Work permit system	
	Working Conditions (6)		Understand hazards associated with particular activity and reduce risk. Safety/pep talk before start of any activity. Issuer, receiver and safety meet to evaluate risk under WPS and suggests mitigation measures Risk at acceptable levels Display of SOPs Display of MSDS at prominent locations	This method exists in the plant
(Function 4) Safety Culture in Organization	Sustainable Safety Performance (4)	Safety Culture	Top management leadership Leadership and commitment at each level of operations Taking safety accountabilities and responsibilities Implementation	This method exists in the plant. There is challenge to adopt leadership and commitment at each level of operations and taking safety accountabilities and responsibilities at all levels.

			of Behaviour Based Safety	
	Safety Management System Software (1)		EHSM SAP System	This method exists in the plant
	Adaptation of Best Safety Practices (2)		Operation and maintenance philosophy based on reputed and inters standards Automation of plants.	This method exists in the plant
	Role of Safety Professionals (2)		Ensure implementation of safety management system Assist Occupier and Factory Manager in fulfillment of safety processes	This method exists in the plant
	Performance Benchmarking (4)		Measuring HSE Performance through HSE Score Review of performance periodically Monitoring milestones against activity. Monthly performance review at OIC level	This method exists in the plant. However, No safety benchmarking could be seen in the plant.
(Function 5) Incident Accident Investigation	Identification and managing system	Near Miss Management	Safety observation and Near miss reporting system	This method exists in the plant

& Analysis	failures (2)		Identify, correct and report unsafe act and condition	
	Incentive for Motivation to report Near Miss (2)		Token gifts and incentives for identifying potential failure scenarios. Near misses shared with employees	
	Common Cause Analysis (3)	Incident Investigation	Multi-disciplinary group to investigate Investigation of incidents Identify root causes of incidents Maintaining data in SAP	This method exists in the plant
	Improve Decision Making (3)		Prevent re-occurrence Compliance of recommendations in time bound manner. Dissemination of incident learnings to employees.	This method exists in the plant
(Function 6) Developing Safety Management	Model of Safety Management (3)	Safety Management	OISD GDN 206 OHSAS 18001 GAIL's HSE Management System	Primarily "Integrated Management System" is in place (ISO 9001, ISO 14001 & OHSAS 18001). Also, they have established organization's

				HSE Management System. Lacuna observed in interlinking of adopted safety management system models.
	Elements of Safety Management (1)		18 Elements HSE Leadership & Commitment Employee Participation Facility Design, Construction& pre-startup review Risk Analysis and management Process safety information Personnel Safety Third party Services Control of Defeat and Reliability of Critical system and Devices Work Permit System Operation & Maintenance Procedures Inspection & Maintenance Management of Change Training Incident Investigation & Analysis Occupational Health Environment Management Emergency Planning and	This method exists in the plant. These elements of organization's safety management system are not clearly defined in IMS (Integrated Management System)

			Response Compliance Audit	
	Management Strategies (4)		Zero accident and zero injury Adopt highest level of safety Clearly defined approach Committed to conduct business with HSEMS	
(Function 7) Regulations		Regulatory (7)	Factory Manager Occupier Regulatory requirements associated in Operations and Maintenance Local safety policy following factory act and rules Compliance of statutory rules and regulations Multiple statutory rules, regulations and statutory authorities.	Multiple Regulations seem to be one of the most sensitive aspects. We need to include it as new construct.

4.3.4 SUMMARY OF FINDINGS OF CASE STUDY 1 (GPP - 1)

- Constructs emerged out from this study are Individual Factors, Organizational Factors, Environment Factors, Safety Culture in Organizations, Managing

Precursors, Incident Investigation & Analysis and developing Safety Management.

- Additionally, a new construct has been identified as ‘Regulations’ for Gas Processing Plant.
- Getting “leadership and commitment” at each level of operations and taking safety accountabilities and responsibilities at all levels is a challenge.
- Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Additionally, Plant has well established organization’s HSE Management System, as well. However, there is lacuna in interlinking between IMS and HSEMS as observed in safety management system elements.
- These elements of organization’s safety management system are not clearly defined in IMS (Integrated Management System).
- There are no international safety performance benchmarking parameters in practice.

4.4 ANALYSIS AND INTERPRETATION OF DATA (CASE STUDY 1: GAS PROCESSING PLANT 2)

4.4.1 INTRODUCTION

Gas Processing Plant of Gas Utility Company is located at District: Guna, Madhya Pradesh. Gas Processing Plant is about 10 KMs from Ruthiyai Railway Station and 30 KMs from District Guna. It is also situated at a distance of 1 KM away from Agra Mumbai Highway No. 3. The installation is receiving Natural Gas by Cross Country Pipelines and is processing Natural Gas to recover Liquefied Petroleum Gas (LPG) and storing and handling petroleum products and NG, in a large volume. The installation is registered under the Factory Act 1948. The installation is also covered under statutes like Petroleum and Explosive Safety Organization (PESO), State Pollution Control Board etc. The installation was started in year 1991. The installation is manned round the clock, deploying workers at about 550 including contract workers. The recovery plant is designed to process natural gas from Cross Country Pipeline and designed to produce

LPG by processing 15 MMSCMD (Million Metric Standard Cubic Meters per Day). The gas processing plant having the storages of LPG, Naptha, Ethyl Mercaptane and High Speed Diesel. During the year 2009-2015, 3 major incidents reported to Oil Industry Safety Directorate (OISD).

4.4.2 DATA COLLECTION

Utilizing Case Study Protocol Semi structured interviews were conducted from the following O&M/ F&S Officials in the area related to Gas Processing Plant- 2.

Table 4.4.1 – List of Interviewees of Case Study-1 (Gas Processing Plant 2)

Level of Analysis	Designation	Date of Interview
Level 1 – Senior Management, Unit Level	General Manager (Operations & Maintenance)	12.08.2017
Level 2 – Middle Management, HODs of Operation/Maintenance/ FS	Chief Manager (Fire & Safety)	11.08.2017
Level 3 – Junior Management Level, Engineers/Supervisors	Senior Manager (Fire & Safety) Manager (Fire & Safety)	10.08.2017 12.08.2017

On the basis of inputs received from interviews "case data analysis" was done taking in to consideration, the research questions. How Gas Processing Plant, plan and execute their Safety Management System and related processes? This helped in identifying different factors which form the base for safety management system and its processes. Further, factors of existing safety management system were found out. Thereafter relationship established between various factors.

The analysis of data was carried out at two stages, at "conceptual" level and at "details" level. The research findings from conceptual analysis were in detail and descriptive. They describe about type of "safety management system" and various safety process adopted, in the organization.

The case analysis results are exhibited in the form of “qualitative associative networks” (See Appendix IV). “Associative networks have nodes linked to each other by association and allows for fuzzy, intuitive and, subconscious relations between concepts to be presented visually”. Representation of associative networks have been done using “boxes” and “arrows”, with the boxes containing the concepts and the arrows representing the relationships among them. The arrows can be “unidirectional” and “bi-directional”. “Relationships can include causality, association, choices, time” (Ryan and Bemard, 2000). The qualitative associative networks created for this case study are shown in Appendix IV.

4.4.3 DESCRIPTION OF EXISTING SAFETY MANAGEMENT SYSTEM

Gas Processing Plant II is an “Integrated Management System” (ISO 9001, ISO 14001 and OHSAS 18001) certified Plant. Along with that they have own Safety Management System established in accordance with Organization’s HSE Management System having 18 elements, considering various aspects of safety management. Safety Management System is mainly governed by OISD 206 guidelines for Petroleum Industries.

HSE Group at Corporate Level as well as at plant level or installation level has been established. HSE Group at Corporate Level formulates HSE Policies in consultation with various levels of Management. This policy is duly approved by CEO of the company. Corporate HSE Group monitors successful implementation of policy and guidelines, which have been formulated by them. This is being done through structured Safety Management System and processes across organization. This document defines the approach for development of Safety Management System, which includes many aspects like Regulatory Requirements, Adopting new technologies, Changes which are there due to new processes, new hazards etc. At Organizational level various aspects like system, resources, guidelines, culture etc are defined. Apart from that it also includes some aspects like competency, skills, training etc.

At plant level Safety Organization, primary roles and responsibilities related to Safety Management lie with Occupier and Factory Manager so as to ensure effective implementation of "Safety Management System" during Operations and Maintenance of the plant. At plant level Safety Department is manned with qualified and experienced executives, who are assisting the Occupier and Factory Manager in fulfilment of safety processes.

Human/individual involvement is one of the most important requirements in safety management. Responsibilities fall with the supervisor to provide appropriate level of competency in terms of qualification, training, knowledge and experience to employees/workers. Provision of adequate and appropriate training pertaining to Safety Management is one of the improvement area identified. Everybody in the plant is empowered to observe, report and stop any unsafe activity at site. Encouraging participation of employees in plant safety committees is in place. Employees are free to put their safety concern with management. Also, "Safety suggestions scheme" is in place to facilitate employees to offer their suggestions on Safety Management, which are encouraged. Good suggestions are discussed in management meetings for improvement. There are set procedures like Standard Operating Procedures, SMPs, Work Permit System, Job safety analysis, strict supervision each and every job, risk analysis for particular job etc. in place. Structured intervention and even informal interaction with workforce is done. During planning of any activity, procedures are laid down to identify risks in plant activities and hazards involved in those activities. Availability of safety procedures and safety measures like PPEs, proper tools, availability of SOP for the specific activity, is ensured. With regard to specific activities which are not of routine, documented system is there to prepare detailed action plan and SOP.

For developing good safety culture, main driving factor is leadership and commitment at the top. Safety is given utmost priority by top leadership. Also, they are challenges, as discussed earlier. Contractual work force is one of the major challenges for plant. There is always blend to contract workers and new entrant employees, who have low understanding of Safety Management System. Providing training, Personal Protective Equipment, clear instructions and close supervision, demand extra to manage them effectively.

Critical observations of Case Study 1: Gas Processing Plant 2 in the above process of data analysis are summarized in the given below Table 7

Table 4.4.2: Open Codes - Case Study 1: Gas Processing Plant 2

SN	Initial Conceptual Constructs	Open Codes
1.	Human/Personal Factors influencing 'Safety' (Function 1: F1)	Round the clock manned operations, Safety Department is manned with qualified and experienced executives, Blend of contract workers and new employees having low understanding on Safety Management System, Lack of competency in Outsourced Workforce, Ground level work is being done through Outsourced Workforce, Contractual workforce identified as safety concern, Employees free to put their safety concerned with management, Empowerment of observe, report and stop any unsafe activity, Openly interact and share their safety concerns, Safety suggestion scheme, Safety/pep talk before start of any activity, In-house training facilities, Hands on training, In-house training to outsourced manpower, Overcome risk behavior of employees, Creating safe behivour of employees, Nomination for BBS observer, Strict supervision for all jobs, Do's and don't for activity, Interaction with workforce etc.

2.	Organizational Factors influencing 'Safety' (Function 2: F2)	Formulation safety policy, Formulation of safety guidelines and procedures at site level, Corporate safety policies approved by CEO, Outline the priorities and level of commitment, Intent for loss control, Reviewing implementation of Safety Management through observance of Monthly Safety Day, Allocation of resources and funds, HSE group at Corporate, Monitor successful implementation of SMS, Safety organization at Unit Level, Plant safety committees, Resources, Fire & Safety group at site, Annual planner/schedule, Pre-planning and prioritizing activities, Standardization of procedures, Detailed maintenance schedule, Inbuilt safety defense system, Identification of hazards and risks associated with activities, Organizing QRA, Quantifying result on risks and consequences, Work Permit System, Mock drills having emergency plans, Conducting mock drills and fire drills at site, Fire detection, Smoke detection, Fire suppression System, Fire Defense system etc.
3.	Environmental Factors influencing 'Safety' (Function 3: F3)	Standard operating procedures for every activity, Conducting job safety analysis, Ensure safe work completion, Work permit system, Identification of hazards and risks associated with activity, Introduction of new hazards, new technologies, Encourage to report unsafe act and condition, Strict supervision for all jobs, Ensuring precautionary like PPE, proper tool, and availability of SOP etc., Various programs and

		competitions, Safety/pep talk before start of any activity etc.
4.	Safety Culture in Organization (Function 4: F4)	Top management leadership, Implementation of Behaviour Based Safety, Clearly defined approach, Management commitment to creating robust and integrated management system, Systemic review process, EHSM SAP System, Leveraging IT application in safety, Operation and maintenance philosophy based on reputed and inters standards, In-built process control, In-built safety defense system, Effective implementation of safety management system, Assist Occupier and Factory Manager in fulfillment of safety processes, Measuring HSE Performance through HSE Score, Achieving HSE Score more than 90, 100% availability of fire protection system, Effective implementation of Safety Management System, Do not have any mechanism to compare our safety performance 'Best in Class' in similar industry etc.
5.	Incident Accident Investigation and Analysis (Function 5: F5)	Near miss reporting can prevent accident, Inevitable near miss incidents, Encouragement and motivation to report near miss, Multi-disciplinary group to investigate, Committee constituted based on severity of incident, Senior executive be part of such committee, Organization's Incident Reporting System, Investigation done in newly EHSM SAP, Techniques like root cause analysis, event tree etc. used in investigation process of an accident, Ascertain root causes and provide

		recommendations to prevent re-occurrence, Sharing case studies to employees, Sharing lesson learnt to employees etc.
6.	Development of Safety Management System (Function 6: F6)	OISD GDN 206, OHSAS 18001, GAIL's HSE Management System, 18 Elements, HSE Leadership & Commitment, Employee Participation, Facility Design, Construction& pre-startup review, Risk Analysis and management, Process safety information, Personnel Safety, Third party Services, Control of Defeat and Reliability of Critical system and Devices, Work Permit System, Operation & Maintenance Procedures, Inspection & Maintenance, Management of Change, Training, Incident Investigation & Analysis, Occupational Health, Environment Management, Emergency Planning and Response, Compliance Audit, Zero accident and zero injury, Adaption of best practices, Clearly defined approach etc.
		Factory Act and Rules, Regulatory requirements associated in Operations and Maintenance, Unit level safety policy signed by occupier and factory manager, Multiple statutory rules, regulations and statutory authorities, OISD and PNGRB, Roles and responsibilities lies to Factor Manager and Occupier etc.

Table 4.4.3: Critical observations on Data Analysis- Case Study 1: GPP 2

Initial Conceptual Constructs	Sub Constructs	Categories basedempirical data	Focused codes developed from empirical data	Observation on Data Analysis

(Function-1) Human/Personal factors influencing Safety F-1	Qualification, Competency and Skills – Regular Employee (2)	Human factors	Round the clock manned operations Safety Department is manned with qualified and experienced executives.	This method exists in the plant
	Qualification, Competency and Skills – Outsourced Workforce (4)	Human factors	Blend of contract workers and new employees having low understanding on Safety Management System. Lack of competency in Outsourced Workforce. Ground level work is being done through Outsourced Workforce. Contractual workforce identified as safety concern.	Managing contractor's safety has not been seen very prominently.
	Motivation (4)		Employees free to put their safety concerned with management Empowerment of observe, report and stop any unsafe activity. Openly interact and share their	This method exists in the plant. Motivation of employees in terms of incentives or award/reward scheme not visible in semi structured

			safety concerns. Safety suggestion scheme	interviews.
	Training (4)		Safety/pep talk before start of any activity In-house training facilities Hands on training In-house training to outsourced manpower.	This method exists in the plant
	Attitude and Behaviour (3)		Overcome risk behavior of employees Creating safe behivour of employees Nomination for BBS observer	This method exists in the plant. At Risk Behaviour of employees are being observed needs methodology to overcome.
	Supervision (3)		Strict supervision for all jobs. Do’s and don’t for activity. Interaction with workforce.	This method exists in the plant.
(Function 2) Organizational Factors influencing Safety F-2	Leadership and Commitment (6)	Organizational Factors	Formulation safety policy Formulation of safety guidelines and procedures at site level. Corporate safety	This method exists in the plant

			policies approved by CEO. Outline the priorities and level of commitment. Intent for loss control Reviewing implementation of Safety Management through observance of Monthly Safety Day.	
	Safety Organization & Resources (7)		Allocation of resources and funds HSE group at Corporate Monitor successful implementation of SMS Safety organization at Unit Level Plant safety committees Resources Fire & Safety group at site	This method exists in the plant
	Design, Operation and Maintenance		Annual planner/schedule	This method exists in the plant

	Practices (5)		Pre-planning and prioritizing activities Standardization of procedures Detailed maintenance schedule Inbuilt safety defense system	
	Risk Analysis and Management (4)		Identification of hazards and risks associated with activities. Organizing QRA Quantifying result on risks and consequences. Work Permit System	This method exists in the plant
	Emergency Planning and Response (6)		Mock drills having emergency plans. Conducting mock drills and fire drills at site. Fire detection Smoke detection Fire suppression System Fire Defense system	This method exists in the plant
(Function 3) Environment	Work Procedures (5)	Environmental Factors	Standard operating	This method exists in the

al Factors influencing Safety F-3			procedures for every activity Conducting job safety analysis Ensure safe work completion Work permit system Identification of hazards and risks associated with activity. Introduction of new hazards, new technologies etc.	plant
	Working Condition (7)		Encourage to report unsafe act and condition. Strict supervision for all jobs. Ensuring precautionary like PPE, proper tool, and availability of SOP etc. Various programs and competitions. Safety/pep talk before start of any activity.	This method exists in the plant
(Function 4) Safety Culture in Organization F-4	Sustainable Safety Performance (5)	Safety Culture	Top management leadership Implementation of Behaviour	This method exists in the plant.

			Based Safety Clearly defined approach Management commitment to creating robust and integrated management system Systemic review process	
	Safety Management System Software (2)		EHSM SAP System Leveraging IT application in safety	This method exists in the plant
	Adaptation of Best Safety Practices (4)		Operation and maintenance philosophy based on reputed and inters standards In-built process control. In-built safety defense system	This method exists in the plant
	Role of Safety Professionals (2)		Effective implementation of safety management system Assist Occupier and Factory Manager in fulfillment of safety processes	This method exists in the plant
	Performance		Measuring HSE	This method

	Benchmarking (5)		Performance through HSE Score Achieving HSE Score more than 90. 100% availability of fire protection system Effective implementation of Safety Management System Do not have any mechanism to compare our safety performance 'Best in Class' in similar industry	exists in the plant. There is no safety benchmarking seen. Do not have any mechanism to compare our safety performance with 'Best in Class' in similar industry
(Function 5) Incident Accident Investigation & Analysis F-5	Identification and managing system failures (2)	Near Miss Management	Near miss reporting can prevent accident Inevitable near miss incidents	This method exists in the plant
	Incentive for Motivation to report Near Miss (1)		Encouragement and motivation to report near miss.	This method exists in the plant. No motivation schemes explained during interview.
	Common Cause Analysis (6)	Incident Investigation	Multi-disciplinary group to investigate Committee constituted based	This method exists in the plant

			on severity of incident Senior executive be part of such committee Organization's Incident Reporting System Investigation done in newly EHSM SAP Techniques like root cause analysis, event tree etc. used in investigation process of an accident.	
	Improve Decision Making (3)		Ascertain root causes and provide recommendations to prevent re-occurrence Sharing case studies to employees. Sharing lesson learnt to employees.	This method exists in the plant
(Function 6) Developing Safety Management F-6	Model of Safety Management (3)	Safety Management	OISD GDN 206 OHSAS 18001 GAIL's HSE Management System	Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Also, they have

				established organization's own HSE Management System. Lacuna observed in interlinking safety management system elements.
	Elements of Safety Management (1)		18 Elements HSE Leadership & Commitment Employee Participation Facility Design, Construction& pre-startup review Risk Analysis and management Process safety information Personnel Safety Third party Services Control of Defeat and Reliability of Critical system and Devices Work Permit System Operation & Maintenance Procedures Inspection & Maintenance Management of Change Training Incident Investigation & Analysis Occupational Health	This method exists in the plant. These elements of organization's safety management system are not clearly defined in IMS.

			Environment Management Emergency Planning and Response Compliance Audit	
	Management Strategies (5)		Zero accident and zero injury Adaption of best practices Clearly defined approach	
(Function 7) Regulations F-7		Regulatory (7)	Factory Act and Rules Regulatory requirements associated in Operations and Maintenance Unit level safety policy signed by occupier and factory manager. Multiple statutory rules, regulations and statutory authorities. OISD and PNGRB Roles and responsibilities lies to Factor Manager and Occupier.	Multiple Regulations seem to be one of most sensitive aspects. It is included as new construct.

4.4.4 SUMMARY OF FINDINGS OF CASE STUDY 1 (GPP 2)

- Constructs emerged out from this study are Individual Factors, Organizational Factors, Environment Factors, Safety Culture in Organizations, Incident Investigation & Analysis and developing Safety Management.
- Additionally, a new construct has been identified as ‘Regulations’ for Gas Processing Plant.
- Additionally, a new sub construct has been identified as ‘Qualification, Competency and Skill – Outsourced Manpower’ for Gas Processing Plant.
- Contract workers and new employees have low understanding on Safety Management System.
- At Risk Behaviour of employees is being observed, however, there is no structured methodology to overcome and improve such behaviours.
- “Communication” or “display of hazards information” and “precautionary/warning” have not been seen, often.
- “Motivation of employees” in terms of incentives or award/reward scheme did not find any mention during semi structured interview.
- Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Additionally, plant has well established organization’s HSE Management System, as well. However, there is lacuna in interlinking between IMS and HSEMS as observed in safety management system elements.
- These elements of organization’s safety management system are not clearly defined in IMS (Integrated Management System).
- There is no international safety performance benchmarking parameters in practice.

4.5 ANALYSIS AND INTERPRETATION OF THE DATA (CASE STUDY 2: REFINERY 1)

4.5.1 INTRODUCTION

This refinery is situated in the district of Panipat, Haryana. It is about 23 km from Panipat historic City. The refinery was built and commissioned in 1998 with 6 MMTPA capacity and Rs. 3868 crore cost including Marketing & Pipelines installations. At the time of commissioning, this refinery was one of India's most advnced refineries. Refinery utilized technologies from France; Denmark; USA etc.. Refinery processes a large range of indigenous and imported variety of crude oil. Refinery receives crude from Vadinar through a cross country pipeline which also supplies crude to other refineries.

Petroleum products get moved from once place to another through various modes like rail, road and pipelines. This Refinery meets the high-consumption demands of North-Western India including the parrts of Rajasthan and Delhi. Refinery is operating above 100% capacity for the so many years and it found to be one of most efficient and modern refinery in India.

4.5.2 DATA COLLECTION

Utilizing Case Study Protocol Semi structured interviews were conducted from the following O&M/ F&S Officials in the area related to Refinery- 1.

Table 4.5.1 – List of Interviewees of Case Study-2 (Refinery 1)

Level of Analysis	Designation	Date of Interview
Level 1 – Senior Management, Unit Level	Dy. General Manager (HSE)	03.04.2018
Level 2 – Middle Management, HODs of Operation/Maintenance/ FS	Sr. Manager (HSE)	05.04.2018
Level 3 – Junior Management Level, Engineers/Supervisors	Manager (HSE)	10.04.2018

On the basis of inputs received from interviews “case data analysis” was done taking in to consideration, the research questions. How Refinery, plan and execute their Safety Management System and related processes? This helped in identifying different factors which form the base for safety management system and its processes. Further, factors of existing safety management system were found out. Thereafter relationship established between various factors.

The analysis of data was carried out at two stages, at “conceptual” level and at “details” level in a similar manner as of Case Study-1 above. The research findings from conceptual analysis were in detail and descriptive. They describe about type of “safety management system” and various safety process adopted, in the organization.

The case analysis results are exhibited in the form of “qualitative associative networks” (See Appendix V). “Associative networks have nodes linked to each other by association and allows for fuzzy, intuitive and, subconscious relations between concepts to be presented visually”. Representation of associative networks have been done using “boxes” and “arrows”, with the boxes containing the concepts and the arrows representing the relationships among them. The arrows can be “unidirectional” and “bi-directional”. “Relationships can include causality, association, choices, time” (Ryan and Bemard, 2000). The qualitative associative networks created for this case study are shown in Appendix V.

4.5.3 DESCRIPTION OF EXISTING SAFETY MANAGEMENT SYSTEM

Oil & Gas Refinery 1 is an Integrated Management System, certified (ISO 9001, ISO 14001 and OHSAS 18001) Plant. They have safety management system in which there are 17 elements and all installations follow the same. These elements include HSE Leadership & Commitment, Employees Participation, Risk Analysis, Process Safety, Personnel Safety, Training, Environment Management, Occupational Health, Emergency Planning etc. HSE Group has been established at Corporate Level. They also have separate HSE group at divisional level. At Other installations there is complete HSE organization or designated safety officer (s). They abide by the policies and guidelines which have been formed with the approval of Board. These HSE groups monitor successful implementation of this policy and guidelines through structured Safety Management System.

Management of this company is dedicated to conduct business with "strong environment consciousness" ensuring sustainable development, "safe work places" and "enrichment of the quality of life of employees, customers and community". As far as the policy is concerned, it binds management to establish and maintain good standard for safety of the people, processes and asset. They comply with all the rules and regulations on safety and occupational health and environment protection. HSE audits of facilities are carried out by external bodies to ensure checks on implementation of safety management system.

Obviously, the employees are major driving force for safe work. Employees are made part of shop floor as well as safety committee meetings. They are also involved in monthly safety day and other activities that are conducted. Employees along with contract workers and CISF are also involved in emergencies drills. Suggestion schemes are in place. The suggestions are invited from employees for improving various safety aspects and if they are found suitable those are duly implemented. Also, employees are suitably rewarded for their suggestions. Online work permit system is implemented through SAP. The permit is issued, accepted and closed in SAP. They have developed website which has separate webpages pertaining to information of Corporate HSE as well as divisional level. At these webpages, employees can access to all the OISD standards, BIS standards, EN Standards, all regulations and investigations of incidents.

The driving force, is the commitment from Top Management Leadership and clear Communication downwards. As far as challenges are concerned, the major challenges are the quantum of contract lobours that are engaged. During the construction, projects as well as operation & shutdown phase, they have vast no. of contract workers entering the installations. But to take care of them, regular meetings, tool box talks, gate meetings are conducted. Contractor supervisors are also advised to impart safety trainings and talks so as to meet the safety requirements.

Critical observations of Case Study 2: Refinery 1 in the above process of data analysis are summarized in the given below Table 4.5.2 & 4.5.3

Table 4.5.2: Open Codes- Case Study 2: Refinery 1

SN	Initial Conceptual Constructs	Open Codes
1.	Human/Personal Factors influencing 'Safety' (Function 1: F1)	Departmental function with minimum manpower, Selection of skilled manpower, Huge quantum of contract laborers, Lethargic to follow safety rules, Empowerment of observe, report and stop any unsafe activity, Safety suggestion scheme Reward/Award to employees, Pre and Post training evaluations, Continuous training and awareness, Quizzes and articles, Refresh the knowledge of people and individual, Regular training to employees, Training on BBS, In-house training facilities & External trainings, Introduction of BBS, Attitude of the personnel, Behaviour of people, By senior people and fire safety personnel in case of critical jobs, Contract supervisor, Watch dog by visiting site etc.
2.	Organizational Factors influencing 'Safety' (Function 2: F2)	Allocation of resources, HSE Policy, HSE Policy signed by CMD, Policy approved by Board, Safety policy and guidelines, Top management commitment, HSE Department, HSE group at CO, HSE group at Divisional level, Firefighting department, HSE organization at site level, Designated Safety Officer, O&M Procedures based on National & International codes and standards, Full-fledged MIS System, OISD

		Standards, BIS Standards, EN Standards etc., Maintained in SAP, Online Work Permit System through SAP, Operation and maintenance procedures, Site selection and technology, System audit, QRA, HAZOP, HAZAN, Conducting mock drills, Firefighting facilities, Fire protection system, Process mock drills etc.
3.	Environmental Factors influencing 'Safety' (Function 3: F3)	Standard operating procedures for every activity, Conducting job safety analysis, Work permit system, Adopt safety practices, Shop floor meeting, Assess hazards associated with activities, Shift management meeting with HODs, Tool box talks, Safety talks with regular and contract workers etc.
4.	Safety Culture in Organization (Function 4: F4)	Top management leadership, Top management commitment, Clear communication from top management, Observe monthly safety day, Monitoring at various levels, SAP System, IT digital platform, Adaptation of National and International Codes, Site selection and technology, Effective implementation of safety management system, Monitor implementation of SMS, PSPI, ISRS approach, Rolling trophy, MoU etc.
5.	Incident Accident Investigation and Analysis (Function 5: F5)	Report unsafe conditions, Online Reporting System, Potential near misses are analyzed, Target to report all near misses including high potential, Token gift for reporting, Defined investigation policy, Involvement of multiple factors, Multi-disciplinary group to investigate, Root cause analysis, Incident investigation and

		analysis, Corrective actions being taken, Learn and take corrective action to prevent reoccurrence, Implement recommendations in other units, Safety statistics maintained in SAP etc.
6.	Development of Safety Management System (Function 6: F6)	OISD GDN 206, OHSAS 18001, Own HSE Management System, 18 Elements, HSE Leadership & Commitment, Employees Participation, Risk Analysis, Process Safety, Personnel Safety, Training, Environment Management, Occupational Health, Emergency Planning etc. Zero accident, Zero Fire, Zero injury, Adaption of best practices, Outline the priorities etc.
7.	Regulations (Function 7: F-7)	Requirements of various guidelines, Difficult to deny district authorities, Statutory rules and regulations, Multiple Statutory rules and regulations etc.

Table 4.5.3: Critical observations on Data Analysis- Case Study 2: Refinery 1

Initial Conceptual Constructs	Sub Constructs	Categories based on empirical data	Focused codes developed from empirical data	Observation on Data Analysis
(Function-1) Human/Personal factors influencing Safety F-1	Qualification, Competency and Skills – Regular Employee (2)	Human factors	Departmental function with minimum manpower Selection of skilled manpower	This method exists in the plant
	Qualification, Competency and Skills – Outsourced Workforce (2)	Human factors	Huge quantum of contract laborers Lethargic to follow safety	This method exists in the plant Contractor

			rules	Safety seems one of issue
	Motivation (2)		Empowerment of observe, report and stop any unsafe activity. Safety suggestion scheme Reward/Award to employees	This method exists in the plant.
	Training (7)		Pre and Post training evaluations Continuous training and awareness Quizzes and articles Refresh the knowledge of people and individual Regular training to employees Training on BBS In-house training facilities & External trainings	This method exists in the plant
	Attitude and Behaviour (3)		Introduction of BBS Attitude of the personnel Behaviour of people	This method exists in the plant.

	Supervision (3)		By senior people and fire safety personnel in case of critical jobs. Contract supervisor Watch dog by visiting site	This method exists in the plant. Supervision from Senior Executives has not been noticed, often.
(Function 2) Organizational Factors influencing Safety F-2	Leadership and Commitment (5)	Organizational Factors	Allocation of resources HSE Policy HSE Policy signed by CMD Policy approved by Board Safety policy and guidelines Top management commitment	This method exists in the plant
	Safety Organization & Resources (6)		HSE Department HSE group at CO HSE group at Divisional level Firefighting department HSE organization at site level Designated Safety Officer	This method exists in the plant
	Design, Operation and		O&M Procedures based on National	This method exists in the

	Maintenance Practices (8)		& International codes and standards Full-fledged MIS System OISD Standards, BIS Standards, EN Standards etc. Maintained in SAP Online Work Permit System through SAP Operation and maintenance procedures Site selection and technology System audit	plant
	Risk Analysis and Management (3)		QRA HAZOP HAZAN	This method exists in the plant
	Emergency Planning and Response (4)		Conducting mock drills Firefighting facilities Fire protection system Process mock drills	This method exists in the plant
(Function 3) Environment	Work Procedures (4)	Environmental Factors	Standard operating	This method exists in the

al Factors influencing Safety F-3			procedures for every activity Conducting job safety analysis Work permit system Adopt safety practices	plant
	Working Condition (5)		Shop floor meeting Assess hazards associated with activities Shift management meeting with HODs Tool box talks Safety talks with regular and contract workers	This method exists in the plant
(Function 4) Safety Culture in Organization F-4	Sustainable Safety Performance (5)	Safety Culture	Top management leadership Top management commitment Clear communication from top management Observe monthly safety day Monitoring at various levels	This method exists in the plant.

	Safety Management System Software (2)		SAP System IT digital platform	This method exists in the plant
	Adaptation of Best Safety Practices (2)		Adaptation of National and International Codes Site selection and technology	This method exists in the plant
	Role of Safety Professionals (2)		Effective implementation of safety management system Monitor implementation of SMS	This method exists in the plant
	Performance Benchmarking (4)		PSPI ISRS approach Rolling trophy MoU	This method exists in the plant. There is no safety benchmarking seen. Do not have any mechanism to compare our safety performance ‘Best in Class’ in similar industry They are not having any mechanism for measuring safety management performance

				based on SMS, periodically.
(Function 5) Incident Accident Investigation & Analysis F-5	Identification and managing system failures (4)	Near Miss Management	Report unsafe conditions Online Reporting System Potential near misses are analyzed Target to report all near misses including high potential	This method exists in the plant
	Incentive for Motivation to report Near Miss (1)		Token gift for reporting	This method exists in the plant. No motivation schemes explained during interview.
	Common Cause Analysis (4)	Incident Investigation	Defined investigation policy Involvement of multiple factors Multi-disciplinary group to investigate Root cause analysis Incident investigation and analysis	This method exists in the plant
	Improve Decision Making (4)		Corrective actions being taken Learn and take corrective action	This method exists in the plant

			to prevent reoccurrence Implement recommendations in other units Safety statistics maintained in SAP	
(Function 6) Developing Safety Management F-6	Model of Safety Management (3)	Safety Management	OISD GDN 206 OHSAS 18001 Own HSE Management System	Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Also, they have established organization's HSE Management System. Lacuna observed in interlinking safety management system elements.
	Elements of Safety Management (1)		18 Elements HSE Leadership & Commitment, Employees Participation, Risk Analysis, Process Safety, Personnel Safety, Training, Environment Management, Occupational Health, Emergency	This method exists in the plant. These elements of organization's safety management system are not clearly defined in IMS.

			Planning etc.	
	Management Strategies (5)		Zero accident Zero Fire Zero injury Adaption of best practices Outline the priorities	
(Function 7) Regulations F-7		Regulatory (4)	Requirements of various guidelines Difficult to denied district authorities Statutory rules and regulations Multiple Statutory rules and regulations	Multiple Regulations seem to be one of most sensitive aspects. It is included as new construct.

4.5.4 SUMMARY OF FINDINGS OF CASE STUDY 2 (REFINERY 1)

- Constructs emerged out from this study are Individual Factors, Organizational Factors, Environment Factors, Safety Culture in Organizations, Incident Investigation & Analysis and developing Safety Management.
- Good safety organization at CO, Divisional and Site level.
- Constructs appeared out from the study are similar with the initial conceptual constructs
- ‘Regulations’ is identified as new construct for Refinery, additionally.
- Huge turnover of Contract Workers in refinery seems a major challenge.
- Practice of motivating employees to report unsafe act and condition not seen.
- Supervision at site to ensure safety compliances is not observed, often.

- Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Additionally, plant has well established organization's HSE Management System, as well. However, there is lacuna in interlinking between IMS and SMS as observed in safety management system elements.
- These elements of organization's safety management system are not clearly defined in IMS (Integrated Management System).
- There is no international safety performance benchmarking parameters in practice.
- They are not having any mechanism for measuring safety management performance based on SMS, periodically.

4.6 ANALYSIS AND INTERPRETATION OF THE DATA (CASE STUDY 2: REFINERY 2)

4.6.1 INTRODUCTION

To meet requirement of Petroleum Products in National Capital Region and North Western Region of country one 6 MMTPA capacity refinery was established in 1982. Refinery was located along the Delhi-Agra National Highway at about 154 KM distance from Delhi. To upgrading environmental standards, old Sulphur Recovery Units (SRU) were replaced with new Sulphur Recovery Units during the year 1999. The Refinery had also established four nos. of new continuous Ambient Air Monitoring Stations far beyond the working area before commissioning of the Refinery in 1982 to show its commitment towards the environment and archaeological sites.

Technological up gradation taken place on continuous basis for Product Quality up-gradation, Energy Conservation and Environment Protection, This Refinery is the first in Asia to receive the coveted “ISO-14001 certification for Environment Management System” in 1996. This refinery get “OHSMS certification for Safety Management in 1998”, first in the World.

4.6.2 DATA COLLECTION

Utilizing Case Study Protocol Semi structured interviews were conducted from the following O&M/ F&S Officials in the area related to Refinery- 2.

Table 4.6.1 – List of Interviewees of Case Study-2 (Refinery 2)

Level of Analysis	Designation	Date of Interview
Level 1 – Senior Management, Unit Level	ED (HSE)	02.02.2018
Level 2 – Middle Management, HODs of Operation/Maintenance/ FS	Dy. General Manager (HSE)	03.04.2018
Level 3 – Junior Management Level, Engineers/Supervisors	Manager (HSE)	10.04.2018

On the basis of inputs received from interviews "case data analysis" was done taking in to consideration, the research questions. How Gas Refinery, plan and execute their Safety Management System and related processes? This helped in identifying different factors which form the base for safety management system and its processes. Further, factors of existing safety management system were found out. Thereafter relationship established between various factors.

The analysis of data was carried out at two stages, at "conceptual" level and at "details" level in a similar manner as of Case Study-1 above. The research findings from conceptual analysis were in detail and descriptive. They describe about type of "safety management system" and various safety process adopted, in the organization.

The case analysis results are exhibited in the form of "qualitative associative networks" (See Appendix VI). "Associative networks have nodes linked to each other by association and allows for fuzzy, intuitive and, subconscious relations between concepts to be presented visually". Representation of associative networks have been done using "boxes" and "arrows", with the boxes containing the concepts and the arrows representing the relationships among them. The arrows can be "unidirectional" and "bi-directional". "Relationships can include causality, association, choices, time" (Ryan and Bemard, 2000). The qualitative associative networks created for this case study are shown in Appendix VI.

4.6.3 DESCRIPTION OF EXISTING SAFETY MANAGEMENT SYSTEM

Oil & Gas Refinery 2 is having "Integrated Management System" i.e ISO 9001, ISO 14001 and OHSAS 18001. Along with OHSAS, Safety Management System has also been established in accordance with organization's HSE Management System having around 17 elements as per OISD Guideline 206. These are derived from Corporate HSE Policy.

They have well defined safety policy which is known as Corporate HSE Policy. It is signed by the top most executive i.e chairman of the organization. Corporate HSE policy describes commitment to conduct business with a robust and "integrated Health, Safety and Environment Management System". Corporate HSE Policy is the apex document which guides the organization in development of Safety Management System at different levels. This document clearly defines the approach for development of Safety Management System. Some of key points are:

- Regulatory Requirements
- Organizational aspects like system, resources, guidelines etc.
- Change in working environment or management of change requirements
- Requirements of Individual aspects on competency, skills, training etc.
- Commitment towards environment protection etc.

Accordingly, different business verticals of the company formulate their local HSE Policy signed by local unit heads.

They have three levels of safety organizations in the company. They have HSE Group at corporate, Divisional and plant level for ensuring safety management implementation. HSE Policy and guidelines are being formulated at corporate level. Corporate HSE department monitors the successful implementation of safety management system/guidelines at refineries. Safety processes are adopted since start of plant. Site selection, proven technology, integrity management system, skilled manpower, specialized trainings etc. are adopted. They have established Operation and Maintenance Philosophy based on reputed National & International Standards. They have work permit system and job safety analysis in place. Apart from these, robust fire protection system has been installed. Main driving force is the commitment from Management Leadership. As far as challenges are concerned heavy turnout of contract workers is considered as one of the challenges. But also, there are well defined processes. Contract personnel are not allowed inside the plant premises until unless they get familiarization training. Their gate pass is endorsed only after getting the training.

Critical observations of Case Study 2: Refinery 2 in the above process of data analysis are summarized in the given below Table 4.6.2 & 4.6.3

Table 4.6.2: Critical observations on Data Analysis- Case Study 2: Refinery 2

SN	Initial Conceptual Constructs	Open Codes
1.	Human/Personal Factors influencing 'Safety' (Function 1: F1)	Continuous persuasion of safety, Expertized and experienced senior management level executives, Skilled manpower, Separate Fire & Safety Department, Heavy turnout of contract manpower, No Knowledge No Fear, Observe, report and stop any unsafe activity, Encourage employees participations, Encourage contract workers giving token prizes, Quarterly plant committee meetings, Safety suggestion scheme, Reward/Award to employees, Allow of contractor workers after training, Engage external agencies for trainings, Field trainings, General and specific trainings, Training imparted to all employees, Pre and post training session test, Structure training system, Specific trainings, To update their knowledge on various safety aspects, Behavioral approach is a leading concern, People mindset, behavioral issues, violation of safety rules and regulations, Working attitude of employees to be changed, Instruct supervisors to guide contractors, Encourage employees and including contractor workers to stop unsafe job and inform supervisor, Regular visits by senior officials etc.

2.	Organizational Factors influencing 'Safety' (Function 2: F2)	Top management commitment towards safety, Clearly defined approach, HSE policy and guidelines, HSE policy signed by CMD, Local HSE policy signed by Local Head, To ensure loss control, Outlines priorities and level of commitment, Formulation of HSE policies and guidelines, Observance of Monthly Safety Day, Conduct business with robust and integrated SMS, HSE group at Corporate, HSE organization at Unit Level, Detailed O&M Procedures based on National & International codes and standards, Proven technology, Manuals and guidelines, Well defined calendar, Maintenance activities are in SAP, Work permit system, Management of Change, Plant safety committees, Risk Analysis and JSA, Fire protection system to two major fires, Robust fire protection system, Automatic fire detection system, Pumping system, Smoke detection etc.
3.	Environmental Factors influencing 'Safety' (Function 3: F3)	Manual and guidelines, Formulation of SOPs, Risk analysis and JSA, Job safety analysis before any critical job, Process failure mock drills, Information about hazards associated with the jobs, Monthly meeting to discuss O&M, Taking feedback from employees, Safety videos, Safety talks to interact with employees etc.
4.	Safety Culture in Organization (Function 4: F4)	Management leadership, Monthly safety day, Subject matter expertise, Top management commitment, Total loss control, E system for

		sharing incident information, HSE Webpage, SAP System, improved technologies, Integrity Management System, Lot of automations, Maintenance activities are in SAP, Operation and maintenance philosophy based on National and International Codes, Proven technology, Formulates HSE policy and guidelines, Ensure implementation of safety management system, Monitor implementation, Measuring lagging indicators, Rolling trophy, MoU, Pre-defined parameters etc.
5.	Incident Accident Investigation and Analysis (Function 5: F5)	Online Near Miss Reporting System, Records maintained in SAP, Token mementos for reporting near miss, Defined investigation process, Data is collected and analyzed, Multi-disciplinary group to investigate, Root cause analysis, Investigation of hypo near misses, Prevent reoccurrence, Dissemination of recommendations, E System for sharing incident information etc.
6.	Development of Safety Management System (Function 6: F6)	OISD GDN 206, OHSAS 18001, Own HSE Management System, 18 Elements, Emergency Planning and Response, Hazard identification & risk analysis, Leadership and commitment, Management of change, Employees Participation, Incident Reporting, Investigation & Analysis, Environment Management, OISD guidelines on safety, Zero accident, Zero Incident, Zero injury, Commitment to conduct business through robust and integrated SMS etc.
7.	Regulations	Regulatory requirements, Multiple statutory

	(Function7: F-7)	rules, regulations and statutory authorities, Meeting requirements of various guidelines, Changing and multiple regulations etc.

Table 4.6.3: Critical observations on Data Analysis- Case Study 2: Refinery 2

Initial Conceptual Constructs	Sub Constructs	Categories based on empirical data	Focused codes developed from empirical data	Observation on Data Analysis
(Function-1) Human/Personal factors influencing Safety F-1	Qualification, Competency and Skills – Regular Employee (4)	Human factors	Continuous persuasion of safety Expertized and experienced senior management level executives Skilled manpower Separate Fire & Safety Department	This method exists in the plant
	Qualification, Competency and Skills – Outsourced Workforce (2)	Human factors	Heavy turnout of contract manpower No Knowledge No Fear	This method exists in the plant. Contractor Safety seems one of the issue.
	Motivation (6)		Observe, report and stop any unsafe activity Encourage employees participations Encourage contract workers giving token	This method exists in the plant.

			prizes Quarterly plant committee meetings Safety suggestion scheme Reward/Award to employees	
	Training (9)		Allow of contractor workers after training Engage external agencies for trainings Field trainings General and specific trainings Training imparted to all employees Pre and post training session test Structure training system Specific trainings To update their knowledge on various safety aspects	This method exists in the plant
	Attitude and Behavior (3)		Behavioral approach is a leading concern	This method does not exist in the plant.

			People mindset, behavioral issues, violation of safety rules and regulations Working attitude of employees to be changed	
	Supervision (3)		Instruct supervisors to guide contractors Encourage employees and including contractor workers to stop unsafe job and inform supervisor Regular visits by senior officials	This method exists in the plant. Supervision from Senior Executives has not been noticed, often.
(Function 2) Organizational Factors influencing Safety F-2	Leadership and Commitment (10)	Organizational Factors	Top management commitment towards safety Clearly defined approach HSE policy and guidelines HSE policy signed by CMD Local HSE policy signed by Local Head To ensure loss control Outlines priorities and level of	This method exists in the plant

			commitment Formulation of HSE policies and guidelines Observance of Monthly Safety Day. Conduct business with robust and integrated SMS	
	Safety Organization & Resources (3)		HSE group at Corporate HSE organization at Unit Level Plant safety committees	This method exists in the plant
	Design, Operation and Maintenance Practices (7)		Detailed O&M Procedures based on National & International codes and standards Proven technology Manuals and guidelines Well defined calendar Maintenance activities are in SAP Work permit system	This method exists in the plant

			Management of Change	
	Risk Analysis and Management (1)		Risk Analysis and JSA	This method exists in the plant
	Emergency Planning and Response (2)		Fire protection system to two major fires Robust fire protection system Automatic fire detection system Pumping system Smoke detection	This method exists in the plant
(Function 3) Environmental Factors influencing Safety F-3	Work Procedures (5)	Environmental Factors	Manual and guidelines Formulation of SOPs Risk analysis and JSA Job safety analysis before any critical job Process failure mock drills	This method exists in the plant
	Working Condition (5)		Information about hazards associated with the jobs Monthly meeting to discuss O&M Taking feedback	This method exists in the plant

			from employees Safety videos Safety talks to interact with employees	
(Function 4) Safety Culture in Organization F-2	Sustainable Safety Performance (5)	Safety Culture	Management leadership Monthly safety day Subject matter expertise Top management commitment Total loss control	This method exists in the plant.
	Safety Management System Software (3)		E system for sharing incident information HSE Webpage SAP System	This method exists in the plant
	Adaptation of Best Safety Practices (6)		Improved technologies Integrity Management System Lot of automations Maintenance activities are in SAP Operation and maintenance	This method exists in the plant

			philosophy based on National and International Codes Proven technology	
	Role of Safety Professionals (3)		Formulates HSE policy and guidelines Ensure implementation of safety management system Monitor implementation	This method exists in the plant
	Performance Benchmarking (3)		Measuring lagging indicators Rolling trophy MoU Pre-defined parameters	This method exists in the plant. There is no safety benchmarking seen. Do not have any mechanism to compare our safety performance 'Best in Class' in similar industry
(Function 5) Incident Accident Investigation & Analysis F-5	Identification and managing system failures (2)	Near Miss Management	Online Near Miss Reporting System Records maintained in SAP	This method exists in the plant
	Incentive for Motivation to report Near Miss (1)		Token mementos for reporting near miss	This method exists in the plant.

	Common Cause Analysis (5)	Incident Investigation	Defined investigation process Data is collected and analyzed Multi-disciplinary group to investigate Root cause analysis Investigation of hypo near misses	This method exists in the plant
	Improve Decision Making (3)		Prevent reoccurrence Dissemination of recommendations E System for sharing incident information	This method exists in the plant
(Function 6) Developing Safety Management F-6	Model of Safety Management (3)	Safety Management	OISD GDN 206 OHSAS 18001 Own HSE Management System	Primarily "Integrated Management System" is in place (ISO 9001, ISO 14001 & OHSAS 18001). Also, they have established organization's HSE Management System. Lacuna observed in interlinking safety management system elements.

	Elements of Safety Management (3)		18 Elements Emergency Planning and Response, Hazard identification & risk analysis, Leadership and commitment, Management of change, Employees Participation, Incident Reporting, Investigation & Analysis, Environment Management OISD guidelines on safety	This method exists in the plant. These elements of organization's safety management system are not clearly defined in IMS.
	Management Strategies (4)		Zero accident Zero Incident Zero injury Commitment to conduct business through robust and integrated SMS	
(Function 7) Regulations F-7		Regulatory (4)	Regulatory requirements Multiple statutory rules, regulations and statutory authorities Meeting requirements of various guidelines Changing and	Multiple Regulations seem to be one of most sensitive aspects. It is included as new construct.

			multiple regulations	

4.6.4 SUMMARY OF FINDINGS OF CASE STUDY 2 (REFINERY 2)

- Constructs emerged out from this study are Individual Factors, Organizational Factors, Environment Factors, Safety Culture in Organizations, Incident Investigation & Analysis and developing Safety Management.
- Good safety organization at CO, Divisional and Site level.
- Constructs appeared out from the study are similar with the initial conceptual constructs
- ‘Regulations’ is identified as new construct for Refinery, additionally.
- Huge turnover of Contract Workers in refinery seems as major challenges. Behaviour related issues emerged at one of the concerned for refinery.
- Scheme of motivating employees to report unsafe act and condition not seen.
- Supervision at site to ensure safety compliances is not observed, often
- Primarily “Integrated Management System” is in place (ISO 9001, ISO 14001 & OHSAS 18001). Additionally, plant has well established organization’s HSE Management System, as well. However, lacuna observed in interlinking between IMS and SMS in safety management system elements.
- These elements of organization’s safety management system are not clearly defined in IMS (Integrated Management System).
- There is no international safety performance benchmarking parameters in practice.

4.7 ANALYSIS AND INTERPRETATION OF THE DATA (CROSS-CASE ANALYSIS)

Data has been analyzed across both the cases (Gas Processing Plant 1 & 2) in this cross-case analysis of the study to identify similarities and differences in planning & execution of Safety Management System Processes and safety in operations and maintenance. By identifying similarities and differences, further insight was obtained into issues concerning the safety management system and its processes (analytically) by generalizing the case study results. The details of similarities and differences are as given under in the Table 4.7.1. Further, propositions suggesting relationships between Individual/Personal Factors, Organizational Factors, Environmental Factors, Managing Precursors, Incident Investigation & Analysis, Developing Safety Management, Safety Culture etc. are also developed.

Table 4.7.1: Similarities &Dissimilarities between Case Study 1 (GPP 1 & 2)

Categories from empirical data (Case Study-1	Focused codes from empirical data (Case Study-1) – GPP 2	Observation on Data Analysis (Case Study-1) GPP 2	Focused codes from empirical data (Case Study -1) GPP 1	Observation on Data Analysis (Case Study -1) GPP 1	Cross –Case Analysis Observations
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills	This method exists in the plant Managing contract's safety has not been seen very prominently.	Qualification, Competency and Skills	This method exists in the plant	Common in both plants
	Motivation	This method exists in the plant Scheme for motivation of employees in terms of incentives or	Motivation	This method exists in the plant	Varies at GPP-1 & GPP-2

		award/reward not visible in semi structured interview.			
	Training	This method exists in the plant.	Training	This method exists in the plant	Common in both plants
	Attitude and Behaviour	This method exists in the plant. At Risk Behaviour of employees are being observed needs methodology to overcome.	Attitude and Behaviour	This method exists in the plant	Varied at GPP 1
	Supervision	This method exists in the plant. Supervision from Senior Executives has not been noticed.	Supervision	This method exists in the plant	Common in both plants
(Function 2) Organizational Factors influencing Safety	Leadership and Commitment	This method exists in the plant	Leadership and Commitment	This method exists in the plant	Common in both plants
	Safety Organization & Resources	This method exists in the plant	Safety Organization & Resources	This method exists in the plant	Common in both plants
	Design, Operation and Maintenance Practices	This method exists in the plant	Design, Operation and Maintenance Practices	This method exists in the plant	Common in both plants
	Statutory Rules and Regulations	This method exists in the plant. Non-compliance to regulatory system seems critical	Statutory Rules and Regulations	This method exists in the plant	Common in both but varies State to State
	Risk Analysis and	This method exists in the	Risk Analysis and Management	This method exists in the	Common in both plants

	Management	plant		plant	
	Emergency Planning and Response	This method exists in the plant	Emergency Planning and Response	This method exists in the plant	Common in both plants
(Function 3) Environmental Factors influencing Safety	Work Procedures	This method exists in the plant	Work Procedures	This method exists in the plant	Common in both plants
	Working Condition	This method exists in the plant	Working Condition	This method exists in the plant	Common in both plants
	Hazards information	Could not determine during interview.	Hazards information	This method exists in the plant	Varied at GPP 1
(Function 4) Safety Culture in Organization	Sustainable Safety Performance	This method exists in the plant	Sustainable Safety Performance	This method exists in the plant. There is challenge to adopt leadership and commitment at each level of operations and taking safety accountabilities and responsibilities at all levels.	Common in both but challenges in GPP 1
	Safety Management System Software	This method exists in the plant	Safety Management System Software	This method exists in the plant	Common in both plants
	Adaptation of Best Safety Practices	This method exists in the plant	Adaptation of Best Safety Practices	This method exists in the plant	Common in both plants
	Role of Safety Professionals	This method exists in the plant	Role of Safety Professionals	This method exists in the plant	Common in both plants
	Performance Benchmarking	This method exists in the plant. There is no safety benchmarking has been seen. Do not have any mechanism to	Performance Benchmarking	This method exists in the plant. There is no safety benchmarking has been seen.	No Benchmarking exists

		compare our safety performance 'Best in Class' in similar industry			
(Function 5) Incident Accident Investigation & Analysis	Identification and managing system failures	This method exists in the plant	Identification and managing system failures	This method exists in the plant	Common in both plants
	Incentive for Motivation to report Near Miss	This method exists in the plant. No motivation schemes explained during interview.	Incentive for Motivation to report Near Miss	This method is exists in the plant	Varied at GPP 1
	Common Cause Analysis	This method exists in the plant	Common Cause Analysis	This method exists in the plant	Common in both plants
	Improve Decision Making	This method exists in the plant	Improve Decision Making	This method exists in the plant	Common in both plants
(Function 6) Developing Safety Management	Model of Safety Management	Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Also, they have established organization's HSE Management System. Lacuna observed in interlinking safety management system models.	Model of Safety Management	Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Also, they have established organization's HSE Management System. Lacuna observed in interlinking safety management system models.	Varied in application in both plants

	Elements of Safety Management	This method exists in the plant. These elements of organization's safety management system in not clearly defined in IMS.	Elements of Safety Management	This method exists in the plant. These elements of organization's safety management system in not clearly defined in IMS.	Varied in applications in both plants
	Management Strategies	This method exists in the plant.	Management Strategies	This method exists in the plant.	Common in both plants
(Function 8) Regulations	Regulations	Regulations seem one of most vulnerable aspects. It is included as new construct	Regulations	Regulations seem one of most vulnerable aspects. It is included as new construct.	Needs more focus

4.7.1 SUMMARY OF FINDINGS OF CROSS-CASE ANALYSIS OF CASE STUDY OBJECTIVE 1 (GPP 1 & 2)

- Constructs emerged out from this study are Individual Factors, Organizational Factors, Environment Factors, Safety Culture in Organizations, Incident Investigation & Analysis and developing Safety Management.
- Constructs appeared out from the study are similar with the initial conceptual constructs
- 'Regulations' is identified as new construct for Refinery, additionally.
- Primarily "Integrated Management System" is in place (ISO 9001, ISO 14001 & OHSAS 18001). Additionally, unit has well established organization's HSE Management System, as well. However, lacuna observed in interlinking between IMS and HSEMS safety management system elements.
- These elements of organization's safety management system are not clearly defined in IMS (Integrated Management System).
- There is no international safety performance benchmarking parameters in practice.

- Applicable Multiple Regulations seem to be one of the most bothering aspects. As such “Regulations” are being included as a new “construct” for research work.
- Contract workers and new employees have low understanding on Safety Management System.
- Managing contractor’s safety has not been seen very prominently
- At Risk Behaviour of employees is being observed, there is no methodology to overcome and improve such behaviors.

Based on the earlier literature on safety management system and processes, six constructs were identified as discussed above. This study found evidence for all these constructs of safety management system and processes along with a new construct “regulations” and a sub construct “contractor’s safety management”. Table-4.7.2 given below shows the cross case comparison of presence of processes and categories of constructs related to safety management system and processes in both the case studies, Gas Processing Plant 1 & 2. ‘1’ in a column denotes the presence of the corresponding category in that case, where as a ‘0’ denotes the absence. Shaded cells show the difference between both cases.

Table- 4.7.2: Cross-Case Comparison of Case Study 1 (GPP 1 & 2)

Categories from empirical data (Case Study-1)	Focused codes from empirical data (Case Study 1)	(Case Study-1) GPP 2	(Case Study -1) GPP 1
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills	1	1
	Motivation	1	1
	Training	1	1
	Attitude and Behaviour	0	1
	Supervision	1	1
(Function 2) Organizational Factors influencing Safety	Leadership and Commitment	1	1
	Safety Organization & Resources	1	1
	Design, Operation and Maintenance Practices	1	1
	Risk Analysis and Management	1	1
	Emergency Planning and Response	1	1
(Function 3) Environmental Factors influencing Safety	Work Procedures	1	1
	Working Condition	1	1
(Function 4) Safety Culture in Organization	Sustainable Safety Performance	1	1
	Safety Management System Software	1	1
	Adaptation of Best Safety Practices	1	1
	Role of Safety Professionals	1	1
	Performance Benchmarking	0	0
(Function 5) Incident Accident Investigation & Analysis	Identification and managing system failures	1	1
	Incentive for Motivation to report Near Miss	0	1
	Common Cause Analysis	1	1
	Improve Decision Making	1	1
(Function 6)	Model of Safety	1	1

Developing Safety Management	Management		
	Elements of Safety Management	1	1
	Management Strategies	1	1
(Function 7) Regulations	Regulations	1	1

Table 4.7.3: Similarities & Dissimilarities between Case Study 2 (Refinery 1 & 2)

Categories from empirical data (Case Study- 2)	Focused codes from empirical data (Refinery 1)	Observation on Data Analysis (Refinery 1)	Focused codes from empirical data (Refinery 2)	Observation on Data Analysis (Refinery 2)	Cross –Case Analysis Observations
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills	This method exists in the plant	Qualification, Competency and Skills	This method exists in the plant	Common in both plants
	Motivation	This method exists in the plant	Motivation	This method exists in the plant Scheme for motivation of employees in terms of incentives or award/reward not visible in semi structured interview.	Common in both plants
	Training	This method exists in the plant.	Training	This method exists in the plant	Common in both plants
	Attitude and Behaviour	This method exists in the plant.	Attitude and Behaviour	This method does not exist in the plant	Varied at Refinery 1
	Supervision	This method exists in the plant.	Supervision	This method exists in the plant	Common in both plants

		Supervision from Senior Executives has not been noticed, often.		Supervision from Senior Executives has not been noticed, often.	
(Function 2) Organizational Factors influencing Safety	Leadership and Commitment	This method exists in the plant	Leadership and Commitment	This method exists in the plant	Common in both plants
	Safety Organization & Resources	This method exists in the plant	Safety Organization & Resources	This method exists in the plant	Common in both plants
	Design, Operation and Maintenance Practices	This method exists in the plant	Design, Operation and Maintenance Practices	This method exists in the plant	Common in both plants
	Risk Analysis and Management	This method exists in the plant	Risk Analysis and Management	This method exists in the plant	Common in both plants
	Emergency Planning and Response	This method exists in the plant	Emergency Planning and Response	This method exists in the plant	Common in both plants
(Function 3) Environmental Factors influencing Safety	Work Procedures	This method exists in the plant	Work Procedures	This method exists in the plant	Common in both plants
	Working Condition	This method exists in the plant	Working Condition	This method exists in the plant	Common in both plants
(Function 4) Safety Culture in Organization	Sustainable Safety Performance	This method exists in the plant	Sustainable Safety Performance	This method exists in the plant.	Common in both plants
	Safety Management System Software	This method exists in the plant	Safety Management System Software	This method exists in the plant	Common in both plants
	Adaptation of Best Safety Practices	This method exists in the plant	Adaptation of Best Safety Practices	This method exists in the plant	Common in both plants
	Role of Safety Professionals	This method exists in the plant	Role of Safety Professionals	This method exists in the plant	Common in both plants
	Performance Benchmarking	This method does not exist in the plant.	Performance Benchmarking	This method exists in the plant.	No Benchmarking exists

		There is no safety benchmarking has been seen.		There is no safety benchmarking has been seen.	
(Function 5) Incident Accident Investigation & Analysis	Identification and managing system failures	This method exists in the plant	Identification and managing system failures	This method exists in the plant	Common in both plants
	Incentive for Motivation to report Near Miss	No motivation schemes explained during interview.	Incentive for Motivation to report Near Miss	No motivation schemes explained during interview.	Common in both plants
	Common Cause Analysis	This method exists in the plant	Common Cause Analysis	This method exists in the plant	Common in both plants
	Improve Decision Making	This method exists in the plant	Improve Decision Making	This method exists in the plant	Common in both plants
(Function 6) Developing Safety Management	Model of Safety Management	Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Also, they have established organization's HSE Management System. Lacuna observed in interlinking safety management system models.	Model of Safety Management	Primarily Integrated Management System is in place (ISO 9001, ISO 14001 & OHSAS 18001). Also, they have established organization's HSE Management System. Lacuna observed in interlinking safety management system models.	Common in both plants
	Elements of Safety	This method exists in the	Elements of Safety	This method exists in the	Common in both plants

	Management	plant.	Management	plant.	
	Management Strategies	This method exists in the plant.	Management Strategies	This method exists in the plant.	Common in both plants
(Function 7) Regulations	Regulations	Regulations seem one of most vulnerable aspects. It is included as new construct	Regulations	Regulations seem one of most vulnerable aspects. It is included as new construct.	Needs more focus

4.7.2 SUMMARY OF FINDINGS OF CROSS-CASE ANALYSIS OF CASE STUDY 2 (REFINERY 1 & 2)

- Constructs emerged out from this study are Individual Factors, Organizational Factors, Environment Factors, Safety Culture in Organizations, Incident Investigation & Analysis and developing Safety Management.
- Constructs appeared out from the study are similar with the initial conceptual constructs
- ‘Regulations’ is identified as new construct for Refinery, additionally.
- Primarily “Integrated Management System” is in place (ISO 9001, ISO 14001 & OHSAS 18001). Additionally, unit has well established organization’s HSE Management System, as well. However, lacuna observed in interlinking between IMS and HSEMS safety management system elements.
- These elements of organization’s safety management system are not clearly defined in IMS (Integrated Management System).
- There is no international safety performance benchmarking parameters in practice.
- Applicable Multiple Regulations seem to be one of the most bothering aspects. As such “Regulations” are being included as a new “construct” for research work.
- Scheme for “Motivation of employees” in terms of incentives or award/reward scheme did not find any mention during semi structured interview.

Based on the earlier literature on safety management system and processes, seven constructs were identified as discussed above. This study found evidence for all these constructs of safety management system and processes along with a new construct "regulations" and "contractor's safety management". Table- 4.7.4 given below shows the cross case comparison of presence of processes and categories of constructs related to safety management system and processes in both the case studies, Refinery 1 & 2. '1' in a column denotes the presence of the corresponding category in that case, where as a '0' denotes the absence. Shaded cells show the difference between both cases.

Table-4.7.4: Cross-case Comparison of Case Study 2 (Refinery 1 & 2)

Categories from empirical data (Case Study-2)	Focused codes from empirical data (Case Study 2)	(Case Study-2) Refinery 1	(Case Study -1) Refinery 2
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills	1	1
	Motivation	1	1
	Training	1	1
	Attitude and Behaviour	1	0
	Supervision	1	1
(Function 2) Organizational Factors influencing Safety	Leadership and Commitment	1	1
	Safety Organization & Resources	1	1
	Design, Operation and Maintenance Practices	1	1
	Risk Analysis and Management	1	1
	Emergency Planning and Response	1	1
(Function 3) Environmental Factors influencing Safety	Work Procedures	1	1
	Working Condition	1	1
(Function 4) Safety Culture in Organization	Sustainable Safety Performance	1	1
	Safety Management System Software	1	1
	Adaptation of Best Safety Practices	1	1
	Role of Safety Professionals	1	1

	Performance Benchmarking	0	0
(Function 5) Incident Accident Investigation & Analysis	Identification and managing system failures	1	1
	Incentive for Motivation to report Near Miss	1	0
	Common Cause Analysis	1	1
	Improve Decision Making	1	1
(Function 6) Developing Safety Management	Model of Safety Management	1	1
	Elements of Safety Management	1	1
	Management Strategies	1	1
(Function 7) Regulations	Regulations	1	1

Table-4.7.5 given below shows the cross case comparison of presence of processes and categories of constructs related to safety management system and processes in both the case studies i.e Gas Processing Plant & Refineries. '1' in a column denotes the presence of the corresponding category in that case, where as a '0' denotes the absence. Safety Management System aspects on Individual Factors 'Attitude and Behaviour' & Developing Safety Management 'Performance Benchmarking' found missing on Gas Processing Plants and Refineries during interviews and secondary documentation. Difficulty in compliance of Multiple Indian Regulations emerged as one of the important factors for Gas Processing Plants and Refineries.

Table-4.7.5: Cross-Case Comparison of Case Study 1 & 2

Categories from empirical data (Case Study- 1 & 2)	**Focused codes from empirical data (Case Study 1 & 2)**	**(Case Study-1) GPP**	**(Case Study -2) Refinery**
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills	1	1
	Motivation	1	1
	Training	1	1
	Attitude and Behaviour	0	0
	Supervision	1	1
(Function 2) Organizational Factors	Leadership and Commitment	1	1

influencing Safety	Safety Organization & Resources	1	1
	Design, Operation and Maintenance Practices	1	1
	Risk Analysis and Management	1	1
	Emergency Planning and Response	1	1
(Function 3) Environmental Factors influencing Safety	Work Procedures	1	1
	Working Condition	1	1
(Function 4) Safety Culture in Organization	Sustainable Safety Performance	1	1
	Safety Management System Software	1	1
	Adaptation of Best Safety Practices	1	1
	Role of Safety Professionals	1	1
	Performance Benchmarking	0	0
(Function 5) Incident Accident Investigation & Analysis	Identification and managing system failures	1	1
	Incentive for Motivation to report Near Miss	1	1
	Common Cause Analysis	1	1
	Improve Decision Making	1	1
(Function 6) Developing Safety Management	Model of Safety Management	1	1
	Elements of Safety Management	1	1
	Management Strategies	1	1
(Function 7) Regulations	Regulations	1	1

CHAPTER 5.0: ANALYSIS AND INTERPRETATION OF THE DATA GPUS & REFINERIES FOR OBJECTIVE 2

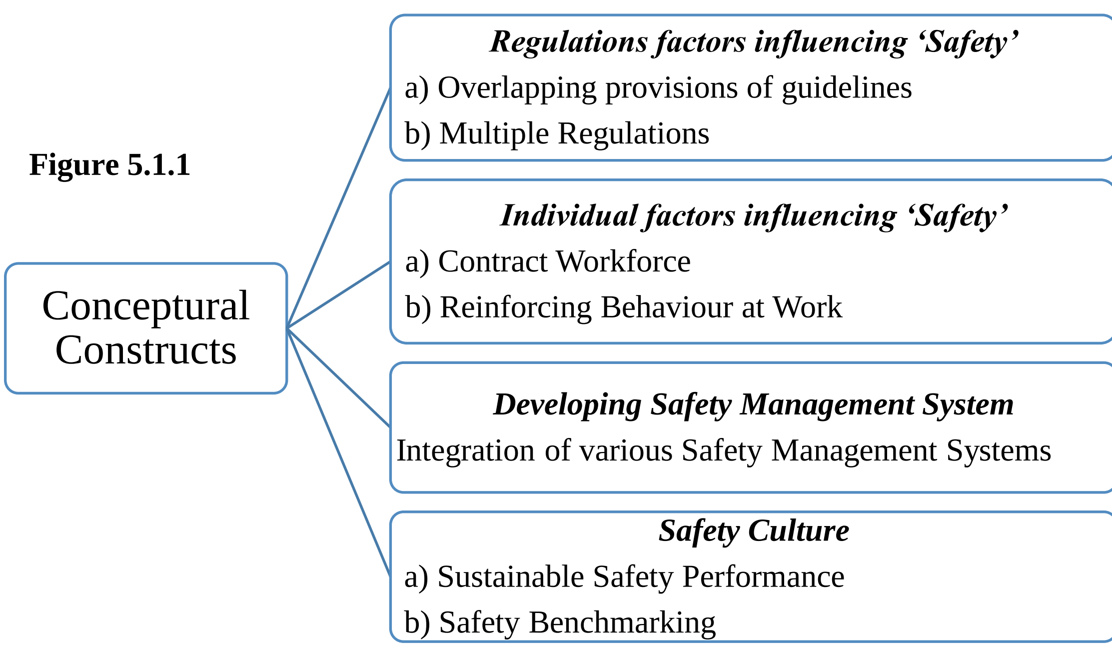
5.1 CONCEPTUAL LENS/CONSTRUCTS FOR THE STUDY

In order to develop the model for Safety Management System in Gas Processing Plants and Refineries, additional constructs were identified during study of existing Safety Management System and cross case analysis in Gas Processing Plants and Refineries, as part of Objective 1.

Table: 5.1.1

SN	Conceptual Constructs	Sub Constructs
1.	Regulations factors influencing 'Safety'	Overlapping provisions of regulations
		Multiple regulations
2.	Individual	Contract Workforce
		Reinforcing Behaviour at work
3.	Developing Safety Management System: Non linkage of various Safety Management Systems	Integration of various Safety Management Systems
4.	Safety Culture	Sustainable Safety Performance
		Safety Benchmarking

Figure 5.1.1



5.2 CASE STUDY PROTOCOL FOR OBJECTIVE 2

A Case Study Protocol for collection of data for Objective 2 i.e To develop a model of "Safety Management System" for Gas Processing Plants and Refineries in India. A Case Study Approach – Data Collection Protocol System of Gas Processing Plants and Refineries is attached as Appendix II.

Threw were 9 questions, primarily covering aspects of Objectives 2 taking inputs received from Cross Case Analysis of Objective 1, which deal with development of a model of "safety management system" for Gas Processing Plants and Refineries in India.

Table: 5.2.1

SN	Conceptual Constructs	Addressing Questions
1.	Regulations factors influencing 'Safety'	2, 3
2.	Individual	4, 5
3.	Developing Safety Management System: Non linkage of various Safety Management Systems	6
4.	Safety Culture	5, 7, 8 ,9

5.3 ANALYSIS AND INTERPRETATION OF THE DATA GPPS

5.3.1 INTRODUCTION

Based on the inputs received from data collection and subsequent analysis, further data have be collected for objective 2 for development of Safety Management System in Gas Processing Plants in India.

5.3.2 DATA COLLECTIONS

Semi structured interviews were organized with following experienced operation, maintenance and fire safety plant personnel in the safety related area using case study protocol:-

Table 5.3.1 - List of interviewees of Case Study (Gas Processing Plants)

Level of Analysis	Designation	Date of Interview
Interview with Senior Management having experience more than 25 years	GM (HSE)	28.04.2018
Interview with Senior Management having experience more than 15 years	DGM (HSE)	28.04.2018
Interview with Senior Management having experience more than 25 years	Chief Manager (HSE)	28.04.2018
Interview with HR-Senior Management having experience more than 8 years	GM (HR)	15.06.2018
Interview with Licensor having experience more than 15 years	CGM	15.06.2018

The case analysis results are exhibited in the form of "qualitative associative networks" (See Appendix IX). "Associative networks have nodes linked to each other by association and allows for fuzzy, intuitive and, subconscious relations between concepts to be presented visually". Representation of associative networks have been done using "boxes" and "arrows", with the boxes containing the concepts and the arrows representing the relationships among them. The arrows can be "unidirectional" and "bi-directional". "Relationships can include causality, association, choices, time" (Ryan and Bemard, 2000). The qualitative associative networks created for this case study are shown in Appendix IX.

5.3.3 DESCRIPTION OF PROPOSED MODEL FOR SAFETY MANAGEMENT SYSTEM IN GAS PROCESSING PLANTS

Various regulations like Factory Acts, Environment Protection Act, Manufacturer Storage and Import of Hazardous Chemical Rules, Petroleum Act, Petroleum and Natural Gas Regulatory Board regulations etc. are applicable to Oil & Gas Industries in India. Provisions under these regulations are mandatory in nature and acts of non-compliance of provisions as made under these regulations is liable for penal actions against Occupier as well as Factory Manager. These regulations not only stipulate the provisions for safety, occupational health and welfare of employees, but also provide direction for designing, operation and maintenance aspects of plant and processes. Hence, in Indian scenarios, all such regulations should be considered as one of the integral facets for developing Safety Management System with other factors like Organizational, Work Environment, and Individual Performance etc. and various provisions of these applicable regulations should be suitably incorporated in Safety Management System.

There are two types of regulations i.e Central and State Regulations. Central Regulations are governed by Central Authorities and are inacted by Parliament of India. However, State Regulations are governed by State Government Authorities. During development of Safety Management System, it should be ascertained that Central as well State wise regulation requirements are defined and incorporated for time bound compliance. Also, we have issues of overlapping provisions in some of the regulations. It is necessary to adopt the stringent stipulations as made under various regulations for compliance, so that other overlapping provisions also get complied with.

Huge number of outsourced manpower has been engaged in organization for operation and maintenance activities. If we look into the accident statistics of last 10 years in hydrocarbon sector alone, injury and fatality rate of these outsourced manpower are comparatively higher than regular manpower. In majority of instances, improper supervision, lack of knowledge, lack of safety consciousness/alertness, lack of competency and skills etc. lead to accidents or injuries. The processes of Gas Processing Plants and Refineries are such that one small human error may lead to cascading effect on operation of facilities, leading to failure along with injury/ loss of life. The issue of ensuring quality outsourced manpower should be kept as one of the key element in Safety Management System. Proper procedures should be developed to ensure engagement of competent outsourced manpower in operation and maintenance. Working Environment procedures should also be reviewed to as to reinforce the safety consciousness among the outsourced manpower prior to entry in the plant, during working in the plant and during exit from plant. These procedures may include safety training and obtaining certificate to that effect, prior to entry in the plant, checking of competency etc. This will help organizations in improving the quality of contract workers.

The process of recognizing and rewarding a desired behavior in an effort to encourage safe behavior at work is known as Positive reinforcement. Praising, offering incentives to continue the behavior or showing appreciation for effort etc. are the processes for reinforcing the same. Reinforcement for purposes such as increasing productivity and improving the morale of an individual or department in the workplace are being used by supervisors. New concept of Behaviour Based Safety has evolved across the world in recent time. This concept may be further evaluated and implemented to reinforce positive safety behavior at work place.

ISO has many standards. However the ISO 9001, quality management system basically formulated on PDCA Cycle i.e Plan, Do, Check & Act principle. This ISO system does not specify any element pertaining to operations, maintenance and safety management in those documents. Whereas, OISD GDN 206 specifies the elements of Safety Management System and associated procedures to carry out the activities of designing, operations and maintenance etc safely. Interlinking of ISO/QMS with Safety Management System will certainly minimize the chances of overlapping the procedures, as stipulated in various documents.

Good organizational safety culture will lead to good safety management system and vice versa. Organizations need to focus on high level of leadership and commitment at all levels, reinforcing positive behavior at work place, defined safety responsibilities and accountabilities, leveraging IT in to safety, comparing safety performance with peer industries etc. This will help in sustaining safety management system in GPUs and Refineries in the long run.

Benchmarking is one of advance concept to evaluate safety performance of organization in comparison with peer organizations. This allows organization to learn best practice adopted by peer organizations. First organizations have to put efforts to benchmark safety processes in comparison with peer industries in India. Accordingly, benchmarking targets and procedures should be developed to achieve those targets.

Critical observations in the above process of data analysis are summarized in Table 5.3.2 & 5.3.3, as given below:

Table 5.3.2: Open Codes- Gas Processing Plants

SN	***Conceptual Constructs***	***Open Codes***
1.	Regulations factors influencing 'Safety'	Factories Act, Petroleum Act, Central Regulations, State Regulations, PNGRB Regulations, MSIHC Rules, Environment Protection Act, Adopt the stringent stipulations etc.
2.	Individual factors influencing 'Safety'	Correct behavior, Positive behavior, Reinforcing safety prior to entry to plant, during plant and exiting to plant, safety training and obtain certificate, Provide adequate resources, Enhances both communication and motivation, Ensuring quality of outsourced workforce, Recognizing and rewarding desired behavours, warrant positive praise, Regular communications with contractor supervisor, showing appreciation efforts, review of contractor procedures etc.
3.	Developing Safety Management System	Formulation of Safety Management System based on Plan, Do, Check and Act Cycle, linking elements of OISD GDN 206 in PDCA cycle etc.
4.	Safety Culture	Leadership at all levels, Adoption of best practices, Comparison with world class performer, Behaviour Based Safety, Leveraging IT to safety, gap w.r.t OISD and PNGRB, reducing lagging indicators, Adopt processes beyond regulations, Making use of valuable data etc.

Table 5.3.3: Critical observations on Data Analysis- Gas Processing Plants

Initial Conceptual Constructs	Sub Constructs	Categories based on empirical data	Focused codes developed from empirical data	Observation on Data Analysis
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills – Outsourced Workforce (7)	Human factors	Reinforcing safety prior to entry to plant, during plant and exiting to plant, Safety training and obtain certificate, Provide adequate resources Enhances both communication and motivation, Ensuring quality of outsourced workforce Regular communications with contractor supervisor Review of contractor procedures etc.	Needs to be included in SMS
	Attitude & Behaviour		Correct behavior Positive behavior Recognizing and rewarding desired behavours	Needs to be included in SMS

			Warrant positive praise Showing appreciation efforts	
(Function 4) Safety Culture in Organization	Sustainable Safety Performance (5)		Leadership at all levels Behaviour Based Safety Leveraging IT to safety Adopt processes beyond regulations Making use of valuable data etc.	Needs to be included in SMS
	Performance Benchmarking (4)		Comparison with world class performer, Gap w.r.t OISD and PNGRB, Reducing lagging indicators, Adopt processes beyond regulations,	Needs to be included in SMS
(Function 6) Developing Safety Management	Model of Safety Management (2)		Formulation of Safety Management System based on Plan, Do, Check and Act Cycle Linking elements of OISD GDN 206 in PDCA cycle	Needs to be included in SMS

(Function- 7) Regulations factors influencing 'Safety'	Regulations (8)		Factories Act Petroleum Act Central Regulations State Regulations, PNGRB Regulations MSIHC Rules Environment Protection Act Adopt the stringent stipulations	Needs to be included in SMS

5.3.4 SUMMARY OF FINDINGS OF CASE STUDY 2 (GAS PROCESSING PLANTS)

- National and State Regulations/Stipulations are one of the integral facets for developing Safety Management System with other factors like Organizational, Work Environment, and Individual/Human etc.
- Safety procedure for engaging Outsourced Workforce should be clearly defined in Safety Management System
- Safety Management System should be developed on PDCA cycle consisting elements of OISD GDN 206.
- Safety Management System should be strengthened by developing safety culture through Leadership at all levels, Adoption of best practices, Comparison with world class performer, Behaviour Based Safety, Leveraging IT to safety, gap w.r.t OISD and PNGRB, reducing lagging indicators, Adopt processes beyond regulations, Making use of valuable data etc.

5.4 ANALYSIS AND INTERPRETATION OF THE DATA OF REFINERIES FOR OBJECTIVE 2

5.4.1 INTRODUCTION

Based on the inputs received from data collection and subsequent analysis, further data have be collected for objective 2 for development of Safety Management System in Refineries in India.

5.4.2 DATA COLLECTIONS

Semi structured interviews were conducted with following experienced operation, maintenance and fire safety plant personnel in the safety related area using case study protocol:-

Table 5.4.1 - List of interviewees of Case Study-2 (Refineries)

Level of Analysis	Designation	Date of Interview
Interview with Senior Management having experience more than 25 years	Ex ED (HSE) Experience more than 28 Years	28.04.2018
Interview with Senior Management having experience more than 15 years	DGM (HSE) Experience more than 15 Years	01.05.2018
Interview with Senior Management having experience more than 25 years	Chief Manager (HSE) Experience more than 8 Years	01.05.2018
Interview with HR-Senior Management having experience more than 8 years	Ex-GM (HR)	29.06.2018
Interview with Licensor having experience more than 15 years	CGM	15.06.2018

The case analysis results are exhibited in the form of “qualitative associative networks” (See Appendix X). “Associative networks have nodes linked to each other by association and allows for fuzzy, intuitive and, subconscious relations between concepts to be presented visually”. Representation of associative networks have been done using “boxes” and “arrows”, with the boxes containing the concepts and the arrows representing the relationships among them. The arrows can be “unidirectional” and “bi-directional”. “Relationships can include causality, association, choices, time” (Ryan and Bemard, 2000). The qualitative associative networks created for this case study are shown in Appendix X.

5.4.3 Description of Proposed Model for Safety Management System in Refineries

Oil & Gas Industries by nature falls under hazardous industries. Various aspects like Factory Acts, Environment Protection Act, Petroleum Act, OISD, PNGRB regulations etc. are applicable to Oil & Gas Sectors in India and they have to follow. These regulations not only stipulate the provisions for safety, occupational health and welfare of employees, they also guide industry on proper design, operation and maintenance aspects of plant. One has to integrate these regulations in safety management system, so that things work well in industries. One has to see that relevant central and state regulations get incorporated in SMS. There will be some difference in state regulations in comparison to central regulations. Industries operating in the states have to be careful in compliance of state regulations, even if there were overlapping of compliances. Stringent stipulations should be adopted to cover all the aspects.

Most of the manpower organizations require for operation and maintenance, in addition to the regular manpower, is outsourced. One cannot avoid outsourced manpower in the system. Only point which can be seen that when they enter in to the system, they should be properly trained and properly examined to ensure that they can understand the system.

Behaviour Based Safety is one of the methodologies which is very successful in developing positive safety behavior and culture. As one take the round of facility, one notices people doing some unsafe behavior at their work, one can stop them in friendly manner and guide such people in presence of their supervisor, so that they convert themselves to people with safe behavior. This exercise is to be repeated number of times till they come out from at risk behavior to safe behavior.

OISD GDN 206 guidelines are basic requirement for any Oil and Gas Industry for adopting safety management system for safe working. ISO standards are one type of system developed internationally to guide us to write our system & procedures well. By looking in to these guiding systems and procedures, elements of OISD GDN 206 should be integrated in Plan, Do, Act & Check cycle.

Leadership has to play very vital role by remaining in touch with middle management as well as lower management, so that they always remain motivated to follow the system and procedures. One can also leverage IT in to safety; compare safety performance with other industries etc. So as to understand best processes of other industries for incorporating improvements. Thus we have to adopt best processes going beyond regulations.

Critical observations in the above process of data analysis are summarized in Table 5.4.2 & 5.4.3, as given below:

Table 5.4.2: Open Codes on Data Analysis- Case Study 2: Refineries

SN	***Conceptual Constructs***	***Open Codes***
1.	Regulations factors influencing 'Safety'	Factories Act, Petroleum Act, Central Regulations, State Regulations, PNGRB Regulations, MSIHC Rules, Environment Protection Act, Adopt the stringent stipulations etc.
2.	Individual factors influencing 'Safety'	Stop at risk behavior in friendly manner, Correct at behavior in to safe behavior, Reinforce safe behavior, Understand to adhere minimum safety

		requirements, Guidance to contractor supervisors, Proper instructions before entry, Proper training and examination etc.
3.	Developing Safety Management System	Formulation of Safety Management System based on Plan, Do, Check and Act Cycle, linking elements of OISD GDN 206 in PDCA cycle etc.
4.	Safety Culture	Leadership at all levels, Comparison safety performance with other industries, Behaviour Based Safety, IT to safety, System ahead of regulations etc.

Table 5.4.3: Critical observations on Data Analysis- Case Study 2: Refineries

Initial Conceptual Constructs	Sub Constructs	Categories based on empirical data	Focused codes developed from empirical data	Observation on Data Analysis
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills – Outsourced Workforce (4)	Human factors	Understand to adhere minimum safety requirements Guidance to contractor supervisors, Proper instructions before entry Proper training and examination	Needs to be included in SMS
	Attitude & Behaviour (3)		Stop at risk behavior in friendly manner Correct at behavior in to safe behavior	Needs to be included in SMS

			Reinforce safe behavior	
(Function 4) Safety Culture in Organization	Sustainable Safety Performance (4)		Leadership at all levels Behaviour Based Safety IT to safety System ahead of regulations	Needs to be included in SMS
	Performance Benchmarking (1)		Comparison safety performance with other industries	Needs to be included in SMS
(Function 6) Developing Safety Management	Model of Safety Management (2)		Formulation of Safety Management System based on Plan, Do, Check and Act Cycle Linking elements of OISD GDN 206 in PDCA cycle	Needs to be included in SMS
(Function- 7) Regulations factors influencing 'Safety'	Regulations (9)		Factories Act Petroleum Act Central Regulations State Regulations, PNGRB Regulations MSIHC Rules Environment Protection Act Adopt the	Needs to be included in SMS

			stringent stipulations Stipulations in other countries	

5.4.4 SUMMARY OF FINDINGS OF CASE STUDY 2 (REFINERIES)

- National and State Regulations/Stipulations are one of the integral facets for developing Safety Management System with other factors like Organizational, Work Environment, and Individual/Human etc.
- Safety Management System should be developed on PDCA cycle integrating with elements of OISD GDN 206, guidelines.
- Safety Management System should be strengthened by developing good safety culture through Leadership at all levels, in comparison with world class performers, Behaviour Based Safety intervention, IT to safety processes, system ahead of regulations etc.

Licenser plays a very important role in designing the facilities with latest technology to reduce the inherent risk of operations to acceptable levels. Data collection was also done from reputed licenser having in-depth understanding of Gas Processing Plants and Refineries in India, as they were involved in designing many such facilities.

These facilities are primarily developed in accordance with International practices, Codes, Standards like ASME, API, EN which specify requirements of quality & safety during, construction, commissioning, operation and maintenance. In addition, National Regulations prescribed by authorities like PESO, PNGRB, OISD and IBR provide elaborate specific quality & safety requirements during design, construction, commissioning, operation and maintenance for the Indian Oil & Gas industry. Provisions under these regulations are mandatory in nature and non-compliance of requirements can lead to non-approval of project or a facility. The Design Basis is a document which enlists all requirements from various regulations (e.g. PESO, IBR, Ministry of Environment & Forest) design codes , best practices, feedbacks and experience. Once this Apex level document is frozen, checklists are prepared for each of the engineering disciplines like Process, Piping, Equipment, Structural etc. During detailed Engineering, these checklists are filled up by the Engineers and counter checked higher level officials. Moreover, during 3D Model Review Specialists from Process Licensor, Operations, Piping and Critical Equipment Suppliers etc. are invited, for getting their specialists input.

Due to migrating nature of outsourced manpower huge human resources are needed to complete any project related to refineries and gas processing plants. One cannot have permanent manpower for each area of work. There will be important role of owner /Owner appointed engineering company in this area. Some of critical areas they have to keep qualified and competent personnel. As far as safety management is concerned, they have to organize induction training for fresher as theyare not aware about the hazards associated with the activities. One has to conduct tool box talks for them and may be some promotional videos. Behaviour based safety remains a challenge for organization. The complexity of facilities and dynamics of resources pose risks of human safety specifically to Outsourced Manpower. Statistics also reveale that rate of incidents are significantly high in construction phase than Operation and Maintenance phases of plant or facilities. In majority of instances, lack of knowledge, lack of safety consciousness/alertness, lack of competency and skills etc. with varied risk pattern led to accidents.

In order to reduce the probability of incidents during the Construction phase, Standard Specification for Health, Safety and Environment Management at Construction Sites should be developed. The Standard Specification encompasses aspects of HSE Policy, Objectives, Deployment and Qualification of Safety Officers and personnel, Behavior Based Safety, Tool Box Talks, HSE Promotion, General and Specialized HSE Training System, Preparation of HIRAC (Hazard Identification and Risk Assessment and Control) Register, and JSAs (Job Safety Analysis) for various construction activities. Such a specification and guidelines prepare a prospective Construction Contractor towards Safety issues. Uniform implementation of explicit requirements by contractors/sub-contractors facilitate organizations in improving the quality of outsourced manpower at construction sites.

One of the measurable safety parameter used for comparison is the frequency rate calculated as “The Number of Lost Time Accidents Per Million Mahhours Worked”. Second important parameter for comparison is The SEVERITY RATE defined as “The Number of ManDays Lost Due to Accidents Per Million Manhours Worked”.

Table 5.4.4

Initial Conceptual Constructs	**Sub Constructs (GPUs)**	**Observation on Data Analysis: GPUs**	**Sub Constructs (Refineries)**	**Observation on Data Analysis: Refineries**
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills – Outsourced Workforce	Needs to be included in SMS	Qualification, Competency and Skills – Outsourced Workforce	Needs to be included in SMS
	Attitude & Behaviour	Needs to be included in SMS	Attitude & Behaviour	Needs to be included in SMS
(Function 4) Safety Culture in Organization	Sustainable Safety Performance	Needs to be included in SMS	Sustainable Safety Performance	Needs to be included in SMS
	Performance Benchmarking	Needs to be included in SMS	Performance Benchmarking	Needs to be included in SMS
(Function 6) Developing Safety Management	Model of Safety Management	Needs to be included in SMS	Model of Safety Management	Needs to be included in SMS
(Function 7) Regulations factors influencing ‘Safety’	Regulations	Needs to be included in SMS	Regulations	Needs to be included in SMS

CHAPTER 6.0: DATA TRIANGULATION FOR OBJECTIVE 1 & 2

There are four tests which are relevant in evaluating quality of any research study: Construct Validity, Internal Validity, External Validity, and Reliability (Yin, 2003). These are discussed below:-

6.1 CONSTRUCT VALIDITY

"Construct validity refers to establishing correct measures for the concepts being studied" (Yin, 2003). This entails that the selected measures (Concepts) are measured correctly. "The potential problems of construct validity can be addressed by data triangulation, when evidence is collected from multiple sources but aimed at corroborating the same fact or phenomenon" (Yin, 2003), and not "when you have multiple sources that nevertheless address different factors" (Yin, 2003). Congregation evidence from a variety of sources essentially provides "multiple measures of the same phenomenon" (Yin, 2003) and ensures "stronger substantiation of constructs and hypotheses" (Eisenhardt, 1989)."

"To address construct validity, triangulation, a technique of combining different sources of evidence in a single study" (Rossman and Wilson, 1985) was used. "This combination of different sources is one of the major strengths of the case study approach" (Yin, 2003). Different sources for collecting/referring required data were organization's web sites, intranet, various documents, interview, observations made during site visits etc. Inputs received during interviews and notes written during observation recording in the field were transcribed and utilized during data analysis. This process increased "construct validity" due to taking into account of multiple perspectives. During field visits for data collections, researcher made good efforts to establish and maintain chain of evidences.

This will allow an external observer to track the deviancy of evidences from initial research questions to ultimate case study conclusion.

After research work, reports were shared with respondent and feedback taken as encouraged by Yin (2003). Final case study reports were generated after incorporating data analysis was done at two levels – "conceptual" and "detailed". "This analysis helped increasing the construct validity of the research by triangulation of perspectives on the same data set (theory triangulation) (Patton, 1990)". The details of triangulations are presented in the below given Table 6.1.1.

Table 6.1.1: Data Evidences for data triangulation of Case Study 1 & 2 (Gas Processing Plant 1 & 2 and Refinery 1 & 2)

Concepts	Categories	Evidence Type	Details of evidences
Planning & Execution of Safety Management System Processes and Systems	Organizational Factors, Environmental Factors & Individual/Personal Factors influencing Safety	1. Interviews 2. Company's Intranet 3. Documents 4. Informal Discussion 5. Participant Observation	1. Audio records & field notes of Interviews 2. Company's Safety Policy available on Intranet 3. Company Annual Report for last 5 years. 4. Company Sustainability Development Report 5. Documents such as ISO documents, Department Quality Manuals, PM Schedules, etc. 6. Field Notes
To develop a model of Safety Management System for Gas Processing Plants and Refineries.	Developing Safety Management	1. Interviews 2. Company's Intranet 3. Documents	1. Audio records & field notes of Interviews 2. Organization's HSE Management System available in Intranet 3. OHSAS 18001 related documents 4. OISD Guidelines

			206 5. Field Notes
	Safety Culture in Organization	1. Interviews 2. Company's Intranet 3. Documents 4. Informal Discussion	1. Audio records & field notes of Interviews 2. Company Annual Report for last 5 years. 3. Company Sustainability Development Report 4. HSE Score System, Behaviour Based Safety etc. available on Intranet 5. Field Notes
	Regulations	1. Interviews 2. Company's Intranet 3. Documents 4. Informal Discussion	1. Factory Act and Rules 2. PNGRB Regulations 3. OISD Standards 4. Other Statutes pertaining to HSE
	Incident Investigation and Analysis	1. Interviews 2. Company's Intranet 3. Documents	1. Audio records & field notes of Interviews 2. Company Sustainability Development Report 3. Organization's Incident Reporting System & EHSM SAP Procedures available in Intranet 4. Analysis of Major Accident released by OISD 5. Field Notes

6.2 INTERNAL VALIDITY

Internal Validity implies “establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships” (Yin, 2003). Generally there are two types of problems which get associated with “inter validity”, “making interferences” and spurious effects”. Since an event cannot be directly observed every time, inferences need to be drawn. Secondly, when there are other factors which were not identified before, in the research design “spurious effect” may happen. Many different facilities were used in research work to take care of such problems and to further improve research validity. First, “theory triangulation, which implies triangulating perspectives on the same data set” (Patton, 1990) was applied. For “with-in case analysis” data was analyzed from “conceptual” and “detailed analysis” perspectives. Second, reports were also shared with respondent and feedback taken for incorporation. Above two tactics enabled better understanding and interpretation of the conceptual studies. To ensure “internal validity” researcher had to focus on better understanding and interpretation of the processes those which could be named as having “causal relationship” between concepts (a cause) leading to other concept (an effects).

6.3 EXTERNAL VALIDITY

External validity implies “establishing the domain to which a study’s finding can be generalized” (Yin, 2003). Generalizability of this research work get strengthened by applying multiple case design. “The design of multiple case studies and cross-case analysis were undertaken according to replication logic, which is same as that which underlies the use of experiments and allows researchers to generalize from one experiment to another” (Yin, 2003).

Replication logic was applied selecting case studies by researcher so as to address external validity. “Case study relies on analytical generalization” (Eisenhardt, 1989, Yin, 2003). Case study does not rely on “statistical generalization” as does the “Experimental hypothesis-testing research". "Once the replication is made, the results may be accepted even though further replications have not been performed" (Yin, 2003).

6.4 RELIABILITY

To minimize the errors and biases in the research work, a reliability test is done. It has been said that "demonstrating that the operations of a study, such as data collection procedures can be repeated, with the same result" (Yin, 2003). "This implies that if another researcher follows the same procedures as applied by a previous researcher for conducting the same (and not another) case study, he/she will arrive at the same findings and conclusions" (Yin, 2003). For achieving consistent application of procedures in data collection and analysis many tactics were utilized in this research work. Firstly, researcher utilized "case study protocol" for the research work. "The protocol is a major tactic in increasing the reliability of case study research and is intended to guide the investigator in carrying out the case study" (Yin, 2003). The "case study protocol" contained the instrument for organizing oral interviews, procedure and general rules for researcher to follow. It was important to have such protocol for getting consistency in data for "within cases" and for the "cross cases". Secondly, it also reduced changes of forgetting or misunderstanding the data. Inputs received during interviews were recorded and written down, so as to enable any other researcher to carry out independent data anlyais. Thirdly, "use of Atlas-Ti software allowed systematic and consistent analysis of qualitative data" (Weitzman, 2000" and "increased the reliability of research because the procedures can be repeated" (Yin, 2003). Fourthly, for future reference and for supporting independent analysis of data by any researcher, even field notes taken during site visits were transcribed..

CHAPTER 7.0: RESULTS

Based on the "Cross Case Analysis" study of Safety Management System of Gas Processing Plants and Refineries for Objective 1 against the Initial Conceptual Constructs and Sub Constructs, focused codes developed from empirical data are written in Table 7.1.1 below.

Table: 7.1.1

Initial Conceptual Constructs	Sub Constructs	Focused Codes Developed from Empirical Data			
		GPP I	GPP II	Refinery I	Refinery II
(Function-1) Human/Personal factors influencing Safety	Qualification, Competency and Skills – Regular Employee	2	2	2	4
	Qualification, Competency and Skills – Outsourced Workforce	0	4	2	2
	Motivation	5	4	2	6
	Training	4	4	7	9
	Attitude and Behavior	2	3	3	3
	Supervision	3	3	3	3
(Function 2) Organizational Factors influencing Safety	Leadership and Commitment	8	6	5	10
	Safety Organization & Resources	4	7	6	3
	Design, Operation and Maintenance Practices	6	5	8	7
	Risk Analysis and Management	4	4	3	1
	Emergency Planning and Response	5	6	4	2
(Function 3) Environmental Factors influencing Safety	Work Procedures	5	5	4	5
	Working Condition	6	7	5	5
(Function 4) Safety Culture in	Sustainable Safety Performance	4	5	5	5

Organization	Safety Management System Software	1	2	2	3
	Adaptation of Best Safety Practices	2	4	2	6
	Role of Safety Professionals	2	2	2	3
	Performance Benchmarking	4	5	4	3
(Function 5) Incident Accident Investigation & Analysis	Identification and managing system failures	2	2	4	2
	Incentive for Motivation to report Near Miss	2	1	1	1
	Common Cause Analysis	3	6	4	5
	Improve Decision Making	3	3	4	3
(Function 6) Developing Safety Management	Model of Safety Management	3	3	3	3
	Elements of Safety Management	1	1	1	3
	Management Strategies	4	5	5	4
(Function 7) Regulations		7	7	4	4

Based upon the methodology [or methodologies] applied to gather information, findings of study for objective 1 & 2 are as follows:

- Primarily "Integrated Management System" (IMS) was found to be in place (ISO 9001, ISO 14001 & OHSAS 18001). Additionally, unit has well established organization's HSE Management System (HSEMS), as well. However, shortcomings were observed in interlinking IMS and HSEMS safety management system elements.
- These elements of organization's safety management system were not clearly defined in IMS (Integrated Management System).
- There was no international safety performance benchmarking parameters in practice.
- Evidence towards managing contractor's safety could not been seen very prominently
- 'At Risk Behaviour' of employees is being observed, but there was no methodology to overcome and improve such behaviors.

- National and State Regulations/Stipulations are one of the integral facets for developing Safety Management System with other factors like Organizational, Work Environment, and Individual/Human etc.
- Detailed procedure for engaging Outsourced Workforce should be clearly defined in “Safety Management System”.
- “Safety Management System” should be strengthened by developing safety culture through Leadership at all levels, Adoption of best practices, Comparison with world class performer, Behaviour Based Safety initiatives, Leveraging IT in safety processes, finding out gaps w.r.t OISD and PNGRB standards and regulations, reducing lagging indicators, Adopting processes going beyond regulations, making use of valuable analytical data etc.

CHAPTER 8.0: DISCUSSIONS

The resolution of the discussion is to understand and describe the significance of findings in depth of "what was already known about the research problem being examined", and "to explain any new understanding or insights about the problem after taking findings into thought".

Following **significant findings** of this research work and contributions to theory, methodology and practice are very important. Over past few years, there has been a need to holistically understand Safety Management System of Gas Processing Plants and Refineries in India. Especially, in an Indian environment this kind of study will contribute a lot towards strengthening safety procedures and systems in Oil & Gas industry.

8.1 FINDINGS OF RESEARCH QUESTIONS

RQ1: How National Gas Processing Plants and Refineries plan and execute their SMS and related processes to ensure safety in operation and maintenance?

Objective: To understand the existing Safety Management System and processes in Gas Processing Plants and Refineries in India.

It has been seen that Gas Processing Plants & Refineries in India have adopted very detailed and structured Safety Management System in line with OISD Guidelines 206 and "OHSAS 18001 (Occupational Health and Safety Assessment Series) Management System". Various constructs have been identified as detailed out under the concept "Safety Management System and Processes" (Refer Network Diagram in Appendix III, IV, V, VI, VII, VIII). Summary of focused codes generated against Initial Conceptual Constructs and Sub Constructs has been placed below:-

Based on the observations, following inferences have been drawn:

- Integrated Quality Management System (ISO) and Safety Management System (in accordance with OISD GDN 206) is in place at Gas Processing Plants and Refineries in India.

- ‘Regulations’ has been identified as new construct for National Gas Processing Plans and Refineries.

- Outsourced manpower is deeply involved in Operation and Maintenance activities. “Contractor’s Safety Management” be considered as one of the critical aspect of “safety management system”. One should ensure adequate level of qualifications, competencies, experiences and skills in the deployed contractor’s manpower, so that they perform jobs safely at site.

RQ2: What should be the comprehensive Safety Management Model applicable to Indian GPUs and Refineries?

Objective: To develop a model of Safety Management System for Gas Processing Plants & Refineries in India.

- Based on the detailed literature review, we could identify seven conceptual constructs which form the basis to existing Safety Management System and related processes. The constructs found are as given under:-

    1. Human/Personal Factors influencing Safety (F1)
    2. Organizational Factors influencing Safety (F2)
    3. Environmental Factors influencing Safety (F3)
    4. Safety Culture in Organization (F4)

5. Incident Accident Investigation & Analysis (F5)
6. Safety Management System Models (F6)
7. Regulatory Factors (F7)

- National and State Regulations in India pertaining to Safety matters are considered key elements for developing any Safety Management System in Oil & Gas Industry.

- It has been inferred from data analysis that Organizational Factors, Environmental Factors, Individual Factors and Regulations applicable to Gas Processing Plants & Refineries are those factors which are primarily impacting the Development of Safety Management of the Installations.

- Integrated Quality Management System (ISO) should be properly linked with Organization' Safety Management System and with stipulated provisions of OISD, PNGRB, Factory Act & Rules and Regulations.

- Incident Accident Investigation & Analysis is one of the elements of OISD "Safety Management System".

- To increase the effectiveness of Safety Management System in an organization good Safety Culture needs to be developed. Leadership and Commitment at all levels, Behavaiour Based Safety initiatives, Safety Responsibilities and Accountabilities at all levels, Safety Benchmarking, Leveraging IT in Safety Practices and effective communication on safety matters have been identified as important elements for developing good Safety Culture.

Accordingly, a theoretical model has been developed and validated with the empirical results utilizing, cross-case analysis method. This model of a "Safety Management System for Gas Processing Plants and Refineries in India" is based on various factors, as identified during study of existing safety management system. The subject model will effectively fill-in the existing gap and shall provide tools to manage Safety Management

System and processes more efficiently, ultimately leading to good safety culture in the organizations.

Figure 8.1.1 – Model of Safety Management System I

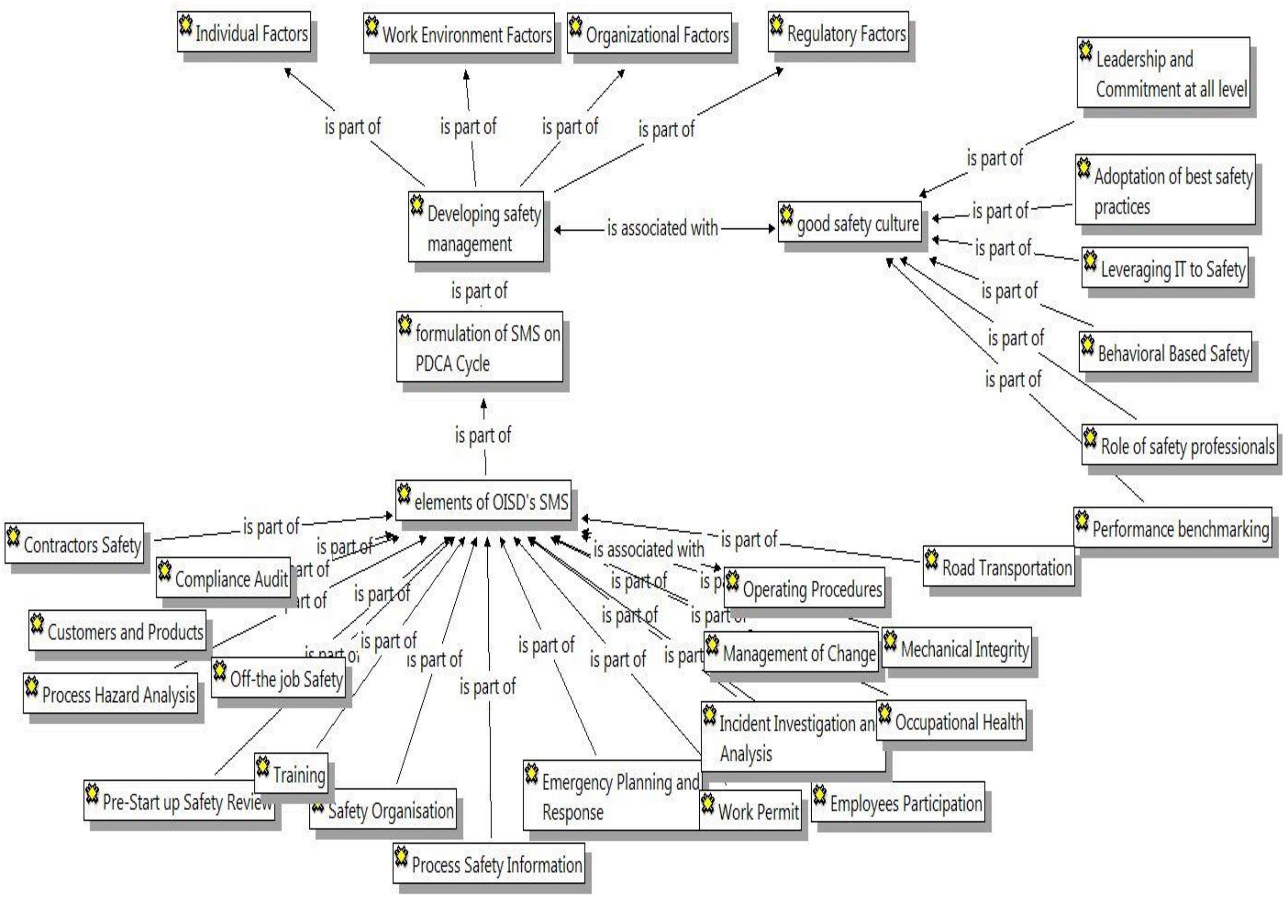
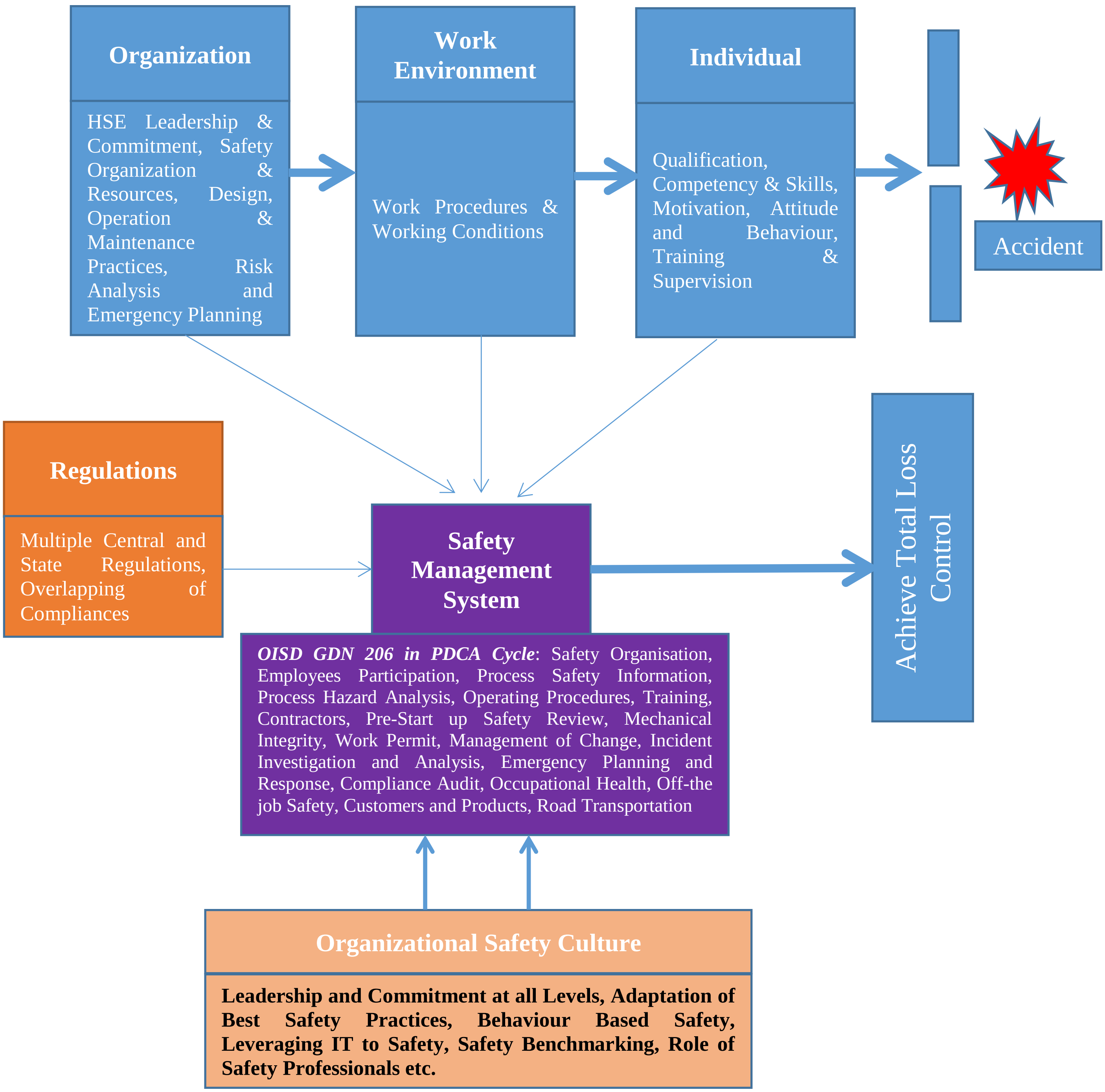


Figure 8.1.2 – Model of Safety Management System II



8.2 THEORETICAL CONTRIBUTIONS

One new type of 'factor' and other 'sub factors' contributing to Safety Management System and processes emerged from the data. These factors/sub factors are very crucial for effective safety management in Gas Processing Plants and Refineries. Taking in to consideration, those new inputs a new model has been developed for getting effective Safety Management System. As such this research work brings significant contribution to existing theories of safety management system, specifically in Gas Processing Plans & Refineries and in general towards Oil and Gas Industries. Following are the contributions:-

a) Identification of factors and sub factors which are influencing Safety Management System

Regulations

The regulatory structure of Oil and Gas Sector has continually been as dynamic as its demand in market and inherent safety risks involved as perceived from past incidents and existing processes. Thus over the years, various rules and regulations w.r.t safety of Oil and Gas Installations have been developed or formulated to ensure adequate safe guard to loss control.

Various regulations like Factory Act & Rules, Environment Protection Act & Rules, Manufacturer Storage and Import of Hazardous Chemical Rules, Petroleum Act, Petroleum and Natural Gas Regulatory Board Regulations etc. are applicable to Oil & Gas Industries in India. Provisions under these regulations are mandatory in nature and non-compliance of provisions as made under these rules makes industry liable for punitive actions. These regulations not only stipulate the provisions for safety, occupational health and welfare of employees, but also provide direction for designing, operation and maintenance aspects of plants, pipelines, other installations and related processes.

Hence, in Indian scenario, relevant stipulations under all such regulations should be considered as one of the integral parts of "Safety Management System", and should be adequately addressed, while writing various elements of Safety Management System.

Organizational Factors influencing 'Safety'

Organization's commitment towards "Safety Management" indicates that top and middle-level management recognizes 'Safety' as a fundamental value of organization demonstrating positive and supportive safety attitudes. For organization having good leadership and commitment, safety organization, safety policy and vision, established design, operation and maintenance policies w.r.t national/international codes and standards, approach to perceive risks and their mitigation etc. are valuable to implement safety programs effectively.

Environmental Factors influencing 'Safety'

Good working environments play very important role in maintaining good safety management system. Working environment consisting of Work Procedures and Working Conditions etc. should be conducive or favorable to work. Otherwise it may lead to errors, mistakes or violations resulting into accident/incident etc..

Individual Factors influencing 'Safety'

Individual/Personal factors are those which relate to a particular individual and can have an effect on, "how they act and behave". This obviously has repercussions on overall health and safety management. Factors such as their competency, skills, attitude, motivation and ability to do the task etc. all influence the way they work and act. Individual factors also get influenced by personal backgrounds, Organization Culture and Work Environments etc.

If one looks at the recent trend in Oil & Gas Industry, engagement of outsourced workers is quite common in practice. The competency and ability of these outsourced workers in India (to understand the hazards associated with Operation and Maintenance in Oil & Gas industry) always remains a question mark. Unless and until Organization has good worker friendly working environment, the design, display and controls, and the role procedures (on the job) clear and adequate, chances of such individual factors influencing Safety Management System adversely, are great.

OHSAS 18001 & OISD GDN 206

As discussed above, Oil and Gas Sector has established their Safety Management System in accordance with OHSAS 18001 and OISD GDN 206 standards and guidelines. OHSAS 18001 provides a outline for “Occupational Health and Safety Management System”, whereas OISD GDN provides detailed guidelines as required for good Safety Management System. As such, any Safety Management System in Oil and Gas Industry should be comprehensive, taking into consideration significant aspects of “Indian Regulations”, “Organizational Factors”, “Environmental Factors” and “Individual Factors”.

Organizational Safety Culture

Safety culture denotes to the behaviors those are adopted to address various safety issues in a workplace. It often reflects “the attitudes, beliefs, perceptions and values that employees share in relation to safety.” Safety culture is a part of “organizational culture”, and has been described by the phrase “the way we do things around here“.

Safety Management System may not be effective, in case organization’s Safety Culture was not encouraging. “Safety” is not one man’s job. It requires collaboration between each and every employee of organization starting from top to bottom, regular to contract employee or consultant to vendor. Organization learning ability w.r.t best practices adopted by peer industries in terms of procedures, leveraging of technologies, robust safety organizations etc. will show a way forward for sustainable implementation of safety management system. Good organizational safety culture will lead to good safety management system and vice versa.

b) A new Model of "Safety Management System" for Gas Processing Plants and Refineries.

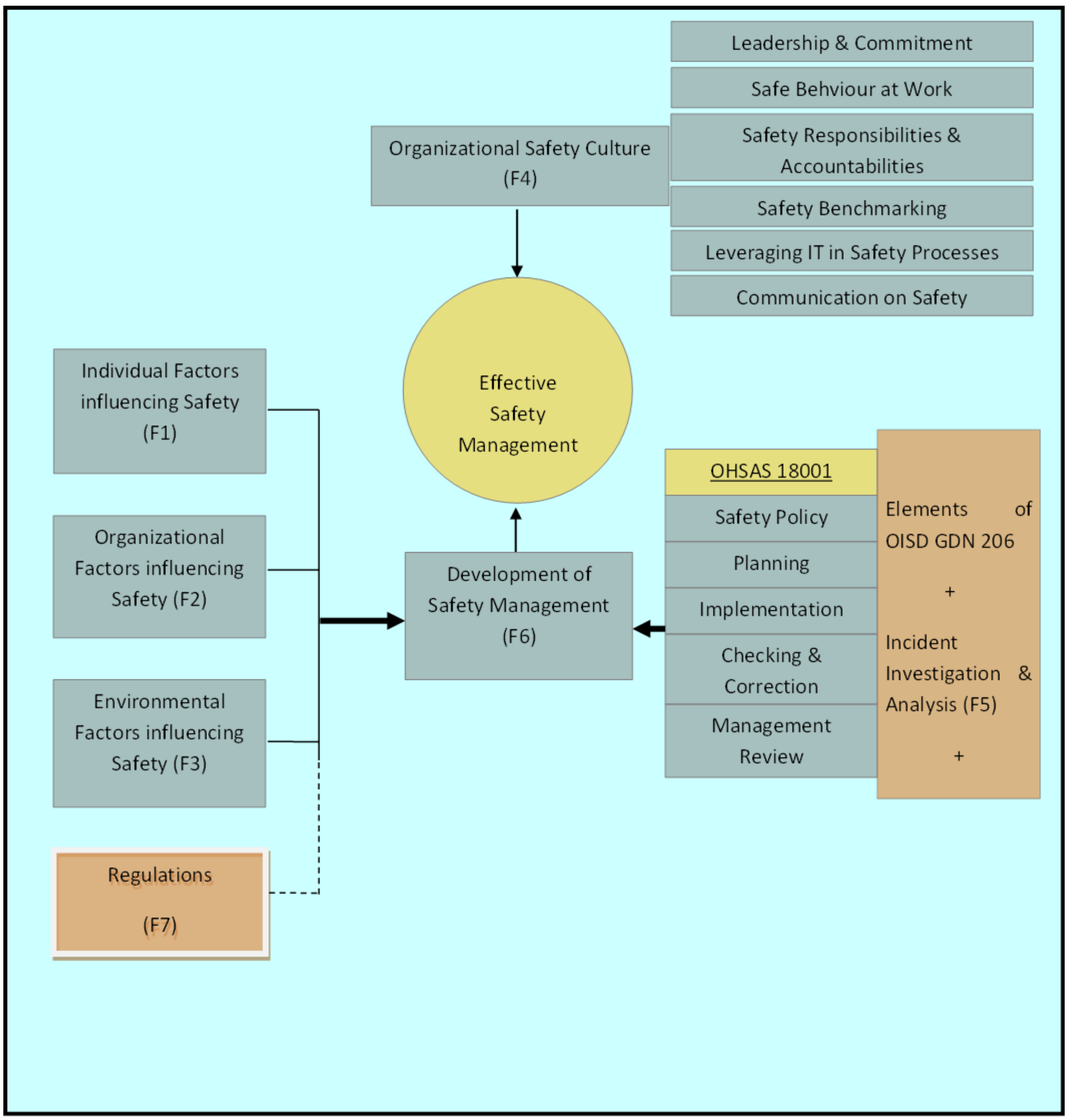


Figure 8.2.1

CHAPTER 9.0: MANAGERIAL IMPLICATIONS

Managerial Implications summarize "what the results mean in terms of actions". In other words, Managerial Implications relate the results to the action standard, and specify what "action" or even "non-action" should be taken in response.

1) Regulatory, Organizational, Environmental factors i.e Work Place Environment and Individual Factors emerged as key factors in development of any "Safety Management System" in Gas Processing Plants and Refineries in India.
2) Identification of 'Safety related' Central and State Regulations needs to be done prior to development of Safety Management System. Those stipulations need to be suitably stitched into Safety Management processes.
3) Safe operation with outsourced Workforce is one of the major challenges in Gas Processing Plants and Refineries. Safety Processes w.r.t to deployment of Outsourced Workforce be precisely addressed in Safety Management System.
4) Applicable aspects of OISD Safety Standard on Safety Management System are required to be made part of existing ISO/OHSAS Management System.
5) Good Safety Culture needs to be developed through Leadership and Commitment, Safety Benchmarking, Behaviour Based Safety initiatives, Introduction of IT in Safety processes, active Employees' Participation etc. for sustainable and effective Safety Management System.

CHAPTER 10.0: CONCLUSIONS

By carrying out detailed in-depth study of Gas Processing Plants and Refineries certain conclusions have been drawn "by applying a qualitative interpretive approach that is often considered as subjective and having limited generalizability" (Klein and Myers, 1999). Various factors identified during research work are based on the perception of interviewees to a large extent, which may be subjective.

Generally, all the Gas Processing Plants and Refineries in India do have quite elaborate "Safety Management System". But, even than accidents are happening in large numbers, causing damage to properties and loss of lives. Given the hazardous nature of the Gas Processing Plants and Refineries, the need for implementation of an efficient Safety Management System is important for improving safety performance and loss control. Resilient thought should be given on Regulatory, Organizational, Environmental and Individual Factors, during the formulation of Safety Management System. Effective Safety Management System is a key to building good safety culture in any organization. However, It is relevant to mention that effectiveness of "Safety Management System" will dependent upon Organizational Culture at large.

CHAPTER 11.0: SUGGESTIONS FOR FUTURE RESEARCH

The outcome of this research work leads to understanding of “Safety Management System” in Gas Processing Plants & Refineries. Various topics could be mentioned for a future research:-

- Further studies could be undertaken to design and conduct surveys in Oil & Gas industry and other industries to test various propositions developed in this research work.

- Researcher can also explore other countries, other work environment and other types of business verticals for research.

- Further studies could generate new “Quantitative Associative Networks” to explore and further enhance researcher’s understanding about “safety management system” processes and implementation strategies for developing good safety culture.

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