EVALUATION OF SAFETY INTERVENTIONS IN AN OIL AND GAS COMPANY

BY

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A thesis submitted to the Department of Industrial and Production Engineering, Bangladesh University of Engineering & Technology, in partial fulfillment of the requirements for the degree of Masters of Engineering in Advanced Engineering Management.

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CERTIFICATE OF APPROVAL

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……….……………..
Md. Alamgir Hussain

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Praise to Allah who has guided me through and has given me the strength of the determination to carry out this work.

At finishing of this journey I realised that I did not do it alone; however I was surrounded by caring people who encouraged, exhorted, and supported me to pursue the race.

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ABSTRACT

In the current global economy, companies tend to be more competitive by endeavoring to keep the good reputation of their organization while maintaining high productivity at the same time. In most cases, non-profit oriented or “invisible” aspects such as health and safety are ignored and as a result, resources are not often allocated for these functions in the budget. With the increasing costs associated with industrial incidents and in an effort to maintain good reputation, several organizations have begun to promote the development of health and safety interventions program.

This thesis intends to provide an overview of a statistical technique to assess a safety interventions program from a business perspective. In the first phase of research, a set of twenty three critical safety interventions has been identified and then five prominent safety interventions are selected from them by Pareto Analysis. In the second phase, a mathematical model is developed by using Multiple Regression Analysis for predicting incident rates. Analysis of Variance test was conducted in order to determine factors and interaction relationships in the model, while response surface methodology was used for optimization of incident rates.

TABLE OF CONTENTS

Contents **Page No.**

Chapter Three: Safety Parameters

Chapter Four: Chevron Safety Principles

Chapter Six: Observation Analysis and Initiatives

Chapter Seven: Data Analysis and Findings

LIST OF TABLES

LIST OF FIGURES

Figures **Page No.**

CHAPTER ONE

INTRODUCTION

1.1 Background & Present State of the Problem

In an age when organizations were required to work with limited and fewer resources, health and safety professionals were not exempt from the discipline of demonstrating effectiveness in meeting business objectives [01]. In low safety performing companies, the management was perceived to be more interested in keeping their safety records than preventing accidents; employees were inadequately trained for their jobs, and were not collectively setting goals for safety [02]. Contemporary safety and health program have over the years been based on theoretical and qualitative analysis. This has prevented industrial organizations and companies from adequately developing and implementing successful health and safety intervention programs aimed at decreasing or eliminating incidents [03].

In an attempt to improve the working environment, several researchers have suggested the creation of a safety culture which enables management to develop hazard free workplace [04]. In this study, an attempt has been made to develop a model of effective safety and health program that incorporates qualitative and quantitative techniques to relate past incident rates, safety resources allocation and intervention activities. Findings from this work offer a new dimension into the practice of statistical analysis of safety intervention activities.

1.2 Objectives with specific aims and possible outcome

The specific objectives of the present research work are as follows:

a) To analyze numbers of safety intervention tools of this company & to sort out best ones from those.
b) To analyze the impact of safety resources in incident rate of drilling & construction projects of an oil & gas company.

c) A safety model is to develop by statistical analysis for the better prediction in incident rate reduction.

The possible outcome of the research work is to predict the effectiveness of safety resources allocation in implementing safety intervention activities; this will in turn minimize the cost of incident prevention initiatives.

1.3 Outline of Methodology

The following step-by-step methodology will be applied to this research project:

a) Data collection of Safety intervention & incident record from the health, environment and safety department of a multinational oil and gas company in Bangladesh.
b) Analyze the impact of safety resource or budget increasing on incident rate reduction and representation by a graphical presentation.
c) Selection of those of the best safety interventions by Pareto Analysis.
d) Development of a safety model in order to determine the safety intervention factors which would be essential to yield the desired incident rate reduction.
e) Obtaining the safety model using Multiple Regression Analysis & using Analysis of Variance for the testing of significance of the model.
f) Using of response surface methodology in the determination of the effectiveness of safety resource allocation.
g) Recommendation of the right proportionate of available resources to be allocated in significant safety intervention activities in order to achieve the desired reduced incident rate at a minimum budget.

CHAPTER TWO

OIL & GAS SECTOR IN BANGLADESH

2.1 Introduction

Bangladesh has proven to be a natural gas giant in the region and to the energy producing community of the world. The Bangladesh sub-surface is according to the present knowledge mainly gas prone, with some potential for future oil discoveries. Within the 1,44,549 sq km of its political territory, Bangladesh has 23 gas fields with some more fields yet to be declared officially as gas fields. Total of 67 exploratory wells including 13 in offshore area have been drilled so far in Bangladesh. The success ratio till now is very encouraging 1:3. In the present energy policy, the present onshore and offshore area of the country has been divided in 23 exploration blocks. Under national and international seismic surveys already three new gas fields have been discovered with high reserve of gas and condensate.

The energy management of the country is thus become most vital for efficient use of its energy resources and the present energy management has been tested to be fruitful for future exploration, production, demand and supply. This sector therefore merits the more attention and importance in the planning of the country compared to any other sector. Under the present energy policy, the gas demand and supply forecast for the short, medium and long development of a gas field. Short and medium term gas demand would be normally met from gas fields close to the trunk lines that would call for a minimum project cost and time, while the long term customers would require dedicated large volume of reserves, field production facilities and transmission pipeline.

Development plan of a gas field is based on the initial evaluation of field reserves, well deliverability, reservoir fluid and reservoir driver. The essence of a gas field development and productions is to ensure maximizing recovery in a cost effective manner. That is why each field or its abandonment. In this southeast region, Bangladesh is comparatively in suitable position in terms of natural gas discovery and production that is powerful enough to lead a nation to gain economic boost.

From the middle-east energy scenario, Bangladesh is determined to take important lessons to learn continuing its search for energy and to utilize the vast amount of energy resources that it has in a planned and systematic way.

This paper will show the ways to develop long term plans for effective management of the present and incoming gas fields of Bangladesh and will emphasize on the techniques to follow for proper development with time [05].

2.2 Safety facts in Bangladesh

Bangladesh is a developing country. Over population, illiteracy and poverty are three major features of this country. In the industrial sector of this country, these three major features play a vital role. In maximum cases workers who start to work in industries are unskilled as they are not provided with sufficient training. These raw hands start to work as unskilled labor and through working in the practical field they become skilled as time goes on. But every year, these workers are experiencing thousands of industrial accidents which lead to different occupational injuries. These injuries have a major effect on the national economy as they cause losses of productive hours, skilled manpower, money as compensation and in addition sufferings to the victims and their family etc. Perhaps enough attention has not paid on this regard because labor is found cheap here [06].

Textile is the most important sector of Bangladesh’s economy. The garment sector now accounts for about 77% of the country’s foreign exchange earnings, and 50% of its industrial work force.

The textiles sector contains many hazards and risks to workers, ranging from exposure to noise and dangerous substances, to manual handling and working with dangerous machinery. Each processing stage from the production of materials to the manufacturing, finishing, coloring and packaging poses risks for workers, and some of these are particularly dangerous for women’s health. Many different groups of chemical substances are used in the textiles sector, including dyes, solvents, optical brighteners, crease-resistance agents, flame retardants, heavy metals, pesticides, and antimicrobic agents. They are used in dyeing, printing, finishing, bleaching, washing, dry cleaning, weaving slashing/sizing, and spinning. Respiratory and skin sensitizers can be found in the textiles industry, for example textiles fibers, reactive dyes, synthetic fibres, and formaldehyde. The exposure of workers to dusts from material such as silk, cotton, wool, flax, hemp, sisal, and jute can occur during weaving, spinning, cutting, ginning, and packaging. Exposure to loud noise can result in permanent hearing damage such as noise-induced hearing loss and tinnitus. Exposure to vibration, particularly together with risk factors for MSDs, can lead to long-term harm.

Electromagnetic fields may also be found in some workplaces in the textiles sector [07].

2.3 History of Oil & Gas sector in safety angle/Incident Records

Bangladesh has been endowed with large potential but limited proven reserves of natural gas that made it important to world energy markets. The country has already been identified to be the hub of energy in the South Asian region. Bangladesh adopted a number of policies since the beginning of 1990s to facilitate the expansion of the private sector and increase the inflow of foreign investments in the energy sector. Due to the growing interests of the Multinational Corporations (MNCs) in the energy sector of Bangladesh, there had been a tremendous optimism over Bangladesh's economic future. Bangladesh looked set to emerge as “South Asia's next success story."

However, some disastrous incidents (Magurchara of Moulovibazar in 1997 and Tengratila of Sylhet in 2005) have unfortunately been experienced which gave rise to poor natural resource management.

A number of managerial, legal, environmental and human rights issues were raised after the incidents. Apparently, the question that arises from those blowouts is whether Bangladesh is entitled to claim adequate damages from the contractors for severely damaging the environment, the economy and the social life of Bangladesh. Both the disasters came to the scene at the time when much attention has been focused on the environmental and human rights impacts of natural resources development, and the upstream sectors of these industries in developing countries have produced some of the detestable cases of environmental and human rights degradations [08].

2.3.1 Magurchara gas field Explosion

Magurchara gas field, 8 km from Srimangal on the road to kamalganj. The gas field caught fire in 1997 and was ablaze for three months, laying waste to betel-nut plantations and tea estates in the vicinity.Generally, in the petroleum sector major activities involved are seismic activities, drilling activities, exploration and production. During those activities the Surrounding areas are affected in various ways. During drilling operations, drilling fluid or mud is continuously circulated through drill pipe and back to the surface equipments to balance underground hydrostatic pressure, to cool the bit and flush out rock cuttings. The location of a drill site depends on the characteristics of the underlying geological formation; however, environmental impacts can be minimized by selecting appropriate site for drilling [09].

Magurchara gas field explosion caused huge damage of life and property over the whole area. The Magurchara gas field explosion damaged about 60 hectors of natural forest and 300 hectors of land were burnt. A large part of wild life (Deer, birds, foxes, monkeys etc) was destroyed or displaced to other places. Around 3000 people were affected because 31 hectors of tea garden was completely damaged during explosion [10]. So, the overall socio-economic and environmental scenario was highly affected by the gas field explosion. Preliminary assessment of environmental damages and deterioration of Magurchara Gas Field Explosion are given in Table 2.1 and its effects on plants, soil and atmosphere are shown in Figure 2.1 which shows the deterioration soil properties, effects on plants on the Magurchara gas field site.

Table 2.1 Preliminary environmental assessment of Magurchara gas field explosion.

Resources	Component	Preliminary assessment
Natural resources	Natural forest	60 ha. completely damaged
		100 ha completely burnt
	Land (300 ha.)	Partly burned observed
		Covered with ash and condensate observed
		Landslide / Land subsidence observed
	Wildlife	Deer, birds, foxes, monkeys etc. destroyed or displaced
	Water logging/ pollution	Observed
Development resources	Tea Garden	31 ha. completely damaged
	Infrastructure	1 km Train line damaged
		1 km Medalled road, 2 culverts damaged
		1 km Gas line
	Livestock	Not observed
	Fisheries	Not observed
Human interest	Local people and Tea garden workers	Around 3000 people affected
	Livestock feeding	Not observed
	Communication and transport	Disrupted
	Socioeconomic disruption	Observed
	Air pollution	Not measured
	Population / market displacement	Not observed

Figure 2.1 Effects of Magurchara gas field explosion on the environment.

Table 2.2 Possible environmental impacts of pipeline construction.

Environmental component	Positive and negative impact	Mitigation measures
Socio-economic	Negative	Providing temporary housing, eating and sanitary facilities for the construction force to prevent overtaxing the local infrastructure
Land use	Negative	Compensation to owners have to be made for crop loss, land should generally be acquired by individual agreement with the owners
Soil fertility	Negative	Soil fertility is to be preserved by segregating the 30 cm. topsoil layer from common fill material during trenching.
Air Quality	Impact is negligible (No)	No mitigation measures are necessary
Surface and groundwater quality	Negative	Potable water used by the construction force have to be tested to ensure that it meets the quality standards of Bangladesh for drinking water. Implementation of Waste Disposal Plan including proper sanitary facilities for the construction force and proper disposal of solid waste generated by the construction activities
Fish and wildlife	Negative	Select alternate routes of pipeline to avoid forest. Construction force has to be prohibited from hunting to prevent further degradation of this limited resource. Natural fish production has to be protected by controlling water pollution.
Historical and archaeology resources	Impact is considered minor (Negative)	

2.3.2 Discussion

Environmental impact assessment of drilling and pipe line activities was predicted for the Magurchara Gas Field exploration in oil and gas sector. A questionnaire was developed and assessment was made based on expert's opinion. 100 experts from different fields related to gas and oil sector were asked and the evaluation was prepared. In Table 2.2, negative and positive were used to classify the magnitude of the environmental parameters with the relevant mitigation measures. The impact on the socio-economic, land use, surface and groundwater quality, fish and wild life is stated as negative where the air quality is negligible. A minor impact is stated on historical and archaeological resources [11].

2.3.3 Tengratila gas field explosion

Again very recently similar disaster in another gas field namely in Tangratila caused even greater hazards both in the environmental, socio-economic as well as human sufferings. This gas field has burnt for couple of months and no instant effective measure was taken by the concerned authority.

The Tengratila gas field, located in Sunamganj, was allotted to Niko Resources, a Canadian company. An explosion in the Tengratila gas field in January 8, 2005, led to 30-40 million cubic feet of gas burning per day. The explosion was heard from miles away and panic-stricken residents fled from their homes. The fire resulted in burning of gas worth 50-60 million dollars. The damage to the soil and ecology may be even greater. Petrobangla blamed the operator, Niko Resources, for not using appropriate equipment and procedures in the drilling process. It was alleged that Niko had not qualified for gas blocks in the 1997 bidding process but was given the gas block outside the regular bidding process, because of its connections. Later, in 2003, it bought Block 9, arguably one of the most prolific gas blocks in Bangladesh, from Chevron Texaco.

Many causes are attributed to the above mishap. In addition to lack of adequate regulations or their enforcement, the government seems to have given exploration contracts to companies with inadequate technical and financial resources. Often these companies have poor safety and environmental records [12].

CHAPTER THREE

SAFETY PARAMETERS

Safety Parameters are primarily divided into two categories, e.g.

a) General Safety Parameters &

b) Incident Related Safety Parameters.

3.1 General Safety Parameters

General safety parameters are the first category of all safety parameters. General safety parameters include Safety, Productivity, Man-hours, Exposure Hours etc. General safety parameters are most important in maintaining safe work practices.

3.1.1 Safety

The average number of man-hours worked per injury normally referred to as the "duration rate". An increasing value denotes improving performance. It is defined as:

(Actual or estimated exposure man-hours in millions) /(No of lost time injuries)

3.1.2 Productivity

Budget field man-hours are generated using information on the project scope, location and execution strategy as well as in house proprietary estimating methods. The ratio of budget man-hours to actual hours was used as an indicator of productivity. Educationally it is defined as:

(Budget field man-hours) /(Actual field man-hours).

For values greater than 1.0 the productivity was better than estimated, and less than 1.0 productivity was worse than estimated. Regression analysis was applied for pairing of Safety & productivity and analysed the results for direction of association and strength of association [01].

3.1.3 Man-Hour

An industrial unit of production equal to the work one person can produce in an hour. Also, a unit for measuring works in industry, equal to the work done by one man in one hour [13].

3.1.4 Exposure Hours

The total amount of man-hours (office, onshore worksite, offshore, etc.) spent on work for (company). This includes Subcontractor man-hours. Onshore hours shall be based on 8 man-hours per day. Offshore hours shall be based on 13 man-hours per day to give a like-for-like comparison with (company) exposure hours.

3.2 Incident Related Safety Parameters

Incident related safety parameters are the second category. Incident related safety parameters includes incident, emergency, First aid case, medical treatment case, restricted work case, days away from work, work related fatality, total reportable case frequency etc.

3.2.1 Incident

An incident is an unplanned event or exposure that has an impact or effect on an employee or contractor, a Chevron owned or leased property, the community or the environment.

3.2.2 Emergency

Emergency is an undesired /unexpected event which suddenly happens and could cause:

- Harm to People
- Damage to Property
- Affect to Environment

3.2.2.1 Example of emergency

- Gas Leak
- Fire/Explosion
- Spills
- Medical
- Natural Disaster
- Bomb Threat
- Vehicle Accident

3.2.2.2 Responsibility of everyone in emergency

- Secure your workplace
- Evacuate from location of emergency
- Rush but do not run
- Gather at the designated muster point
- Follow on scene commander’s command
- Do not return to work until all clear is given by Person-in-Charge

3.2.3 First Aid Case (FAC)

Any single treatment and subsequent observation of minor scratches, cuts, burns, splinters, etc. that do not normally require medical care by a physician. Such treatment and observation is considered first aid case even if provided by a physician or registered professional personnel.

Note that FAC is not included into TRC.

3.2.4 Medical Treatment Case (MTC)

Any work related injury that involves neither lost workdays nor restricted workdays, but which requires treatment by a physician or other medical specialist.

In case an MTC has been classed as LWC or LTI, then avoid reporting it as MTC.

3.2.5 Restricted Work Case (RWC)

Any work related injury which renders the injured person temporarily unable to perform all, but still some, of their normal work on any day after the day on which the injury occurred.

3.2.6 Days Away From Work (DAFW)

If anybody become ill from any work related injury and could not come to work for those days he could not come to work is called DAFW.

3.2.7 Work Related Fatality (FAT)

A death resulting from a work related injury or occupational illness, regardless of the time intervening between the exposures or incident causing the injury or illness and the death is called FAT.

3.2.8 Total Reportable Case Frequency (TRCF)

A twelve month rolling average total reportable case frequency is calculated per one million man-hours. Man-hours are based on a twelve hour working day or actual hours worked if recorded [14]. Total Reportable Case Frequency (TRCF) is defined as:

TRCF = (TRC / exposure hours) x 1,000,000

CHAPTER FOUR

CHEVRON SAFETY PRINCIPLES

4.1 Contractor HES Management (CHESM)

Managing contractors is a guide for small to medium sized companies in the chemical industry. Safe working with contractors always presents a big challenge, but not impossible. Contractor HES Management includes different kinds of Health, Environment and Safety tools. As for example: Hazards, Hazard Identification Tools, Energy Source of Hazard, Behavior-Based Safety, Stop Work Authority, Near Miss, Think Incident-Free etc.

4.1.1 Hazards

A condition or action that has the potential for an unplanned release of, or unwanted contact with, an energy source that may result in harm or injury to people, property or the environment.

4.1.1.1 Hazard Identification Tool

- A visual aid that helps you focus on hazard identification.
- A tool that helps you identify hazards based on energy source identification.
- A simple method to help you complete daily activities and tasks safely and reliably.
- A tool which easily integrates with existing hazard assessment methodologies such as JSA, SPSA, HA, JHA, PHA, THA, TIF, JLA, etc.

4.1.1.2 Energy Source of Hazard

- Gravity
- Motion
- Mechanical

- Electrical
- Pressure
- Temperature
- Chemical
- Biological
- Radiation
- Sound

4.1.2 Behavior-Based Safety (BBS)

The Behavior-Based Safety (BBS) process is aimed at preventing injury to employees and contractors through reinforcement of safe behaviors and reduction of at-risk behaviors in the workplace.

4.1.2.1 Behavior

- An observable action
- Can be desired or undesired
- Must be objectively defined

4.1.3 Stop Work Authority (SWA)

Stop Work Authority (SWA) is the responsibility and authority of any individual to stop work when an unsafe condition or act could result in an undesirable event. In general terms, the SWA process involves a stop, notify, correct, and resume approach for the resolution.

4.1.3.1 Condition/situations for giving SWA

1. Unsafe conditions
2. Incident occurs

3. Significant near-miss
4. Emergency situation
5. Alarm sounds
6. Change in conditions
7. Change in scope of work
8. Change in work plan
9. Anytime anyone feels that personnel, the environment, or equipment is at risk

4.1.4 HID/Near Miss

A near miss is any unplanned event having a potential but unrealized consequence for injury/illness or damage to property, the environment, the company’s reputation or financial performance.

- Examples*:*
  - Someone trips over a pallet, but doesn't fall
  - A nonfunctioning safety device.

4.1.5 Conduct Think Incident-Free (TIF)

Think Incident-Free should be used by everyone prior to beginning any activity. The intend of the Think Incident-Free is to:

- To prompt workers to think before they act.
- To ensure that the worker is looking for hazards while they are doing work.
- To support Stop Work Authority and the Tenets of Operation.
- Individual must take responsibility for his or her own health and safety in all activities, as well as protecting the environment.

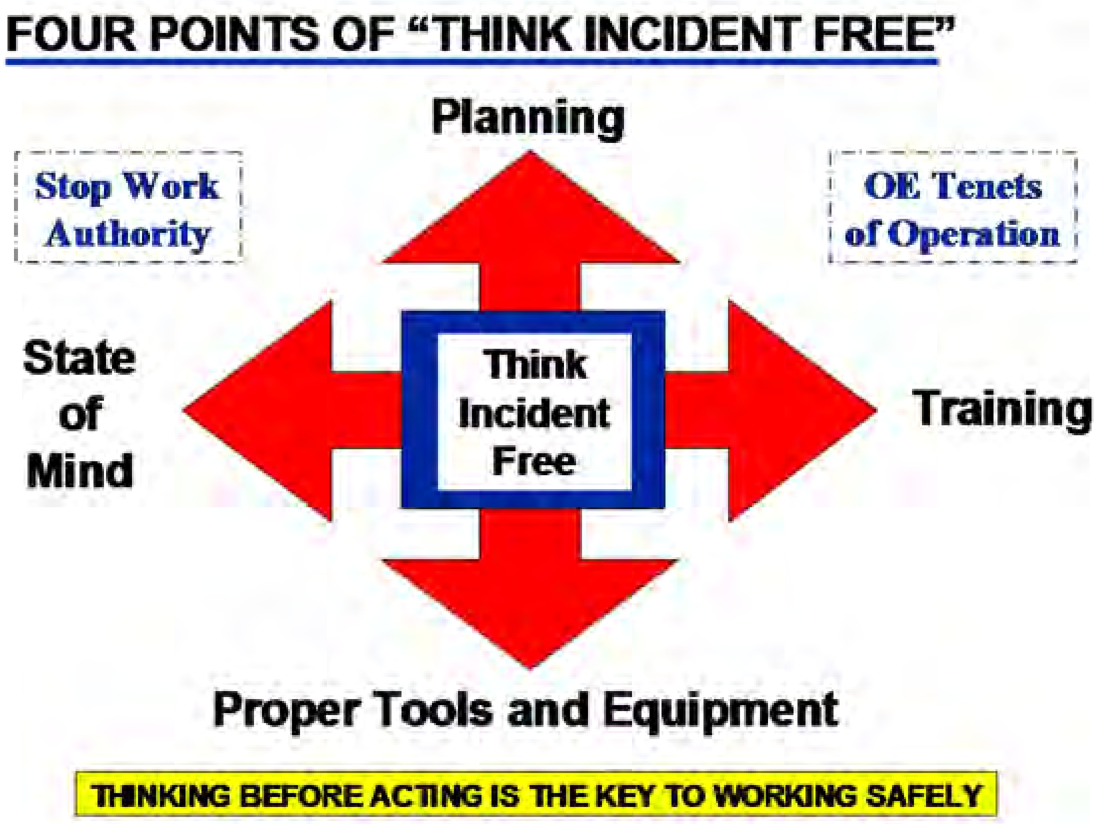


Figure 4.1 Think Incident-Free (TIF)

4.2 Chevron's Safe work Practices & Procedures

The purpose of Chevron's Safe work Practices & Procedures is to identify, assess, and mitigate, control or eliminate the risks associated with work. The Managing Safe Work (MSW) process provides for the identification and evaluation of job task hazards, specification of control measures, management of those measures, control of the work, and behaviors to support safe work.

4.2 .1 Documentations

Chevron's Safe work Practices & Procedures includes all kinds of documentations required to maintain all works safely. These documentations include Hazard Analysis, Job Safety Analysis, all kinds of Permits etc.

4.2 .1.1 HA (Hazard Analysis)

A Hazard Analysis (HA) involves five steps:

- Identifying the job (task)
- Forming the HA team (for simple tasks, this may be one person)
- Breaking down the job (task) into steps
- Identifying potential hazards with energy sources
- Developing solutions/control measures to mitigate the identified hazards with risk assessment

4.2.1.1.1. Identifying the Job

a) All jobs (tasks) shall be evaluated using the Hazard Analysis procedure.
b) A job (task) is a sequence of steps or activities to complete the work.
c) Some jobs are too broad for an HA, such as "drilling a well" or "performing a shut down on a crude unit."
d) Some job steps are too narrow for effective analysis, (e.g., "turning on a switch").
e) The appropriate level of detail for a task means type of assignments in a step that a supervisor would make (e.g., "removing a pump for maintenance, collecting an oil sample from a vessel," or "installing a blind in piping").

4.2.1.1.2. Forming the HA Team

a) Person(s) performing the HA should meet the following requirements:
   i. Be experienced and knowledgeable about the job
   ii. Have credibility with the work group
   iii. Understand the HA procedure
b) Team make-up depends on factors such as the job (task) being evaluated, the location of the work and the size of the work group who will perform the task.
c) It may be acceptable for an HA to be prepared by one person.
d) HAs may be initiated in an office setting; however, site visits by the person(s) conducting the HA are required to complete the analysis.

4.2.1.1.3. Breaking Down the Job

a) The job is broken down into a sequence of steps, each describing what is being done, not how.
b) Begin by asking “What step starts the job?” then, “What is the next basic step?” and so on.
c) If too many steps result from the analysis (over 15), consider breaking that job into more than one task.
d) The description for each step should begin with an action word like, “remove, climb, open” or “weld.”

4.2.1.1.4. Identifying Potential Hazards

a) Once the basic steps have been determined, begin the search for all potential and existing hazards.
b) Look for the energy sources
c) Look at physical conditions (chemicals, tools, work space, etc.), environmental factors (heat, cold, noise, lighting, wet conditions, etc.) and actions or behaviors (need to stand on a slippery or unstable surface, extended reach to operate a valve, lifting bulky objects).

4.2.1.1.5. Developing solutions/control measures

a) Developing solutions/control measures to mitigate the identified hazards with risk assessment
b) If the surface is slippery, then the hazard is –‘slip-trip-fall/gravity’ then the solution will be-‘Keep Eyes on Path’.

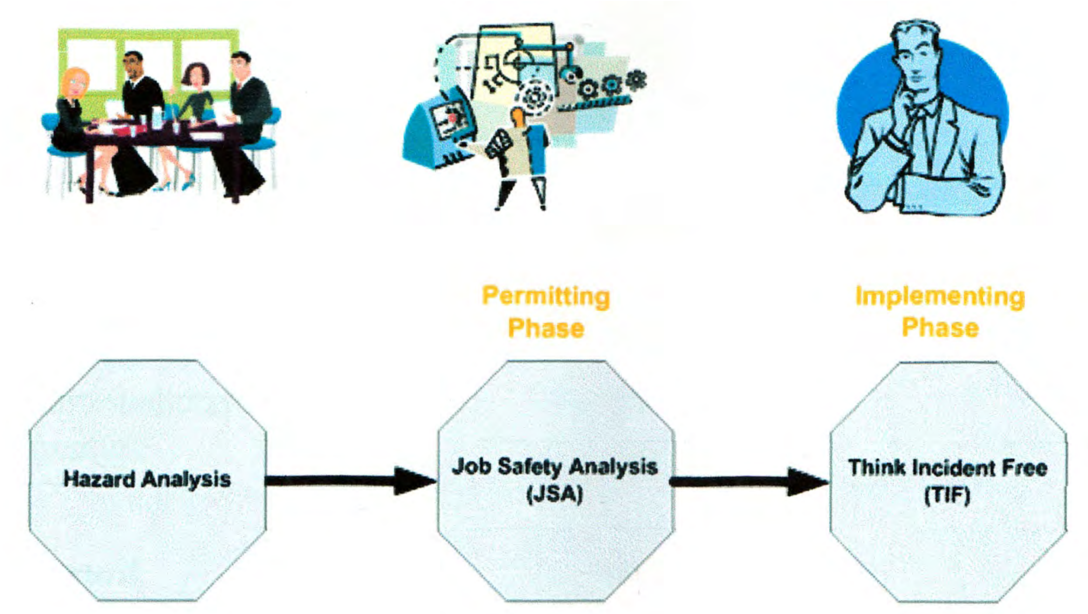


Figure 4.2 Phases of Hazard Analysis

4.2 .1.2 Job Safety Analysis (JSA)

- Shall be performed onsite prior to the initiation of work. The purpose of the onsite JSA is to:
  - Involve the work team to make sure that the people doing the work understand the tasks, hazards and mitigations
  - Address on-site conditions on the day of the work
  - Verify that work team has proper skill level and tools

- Other factors:
  - It should be developed in the language appropriate for the entire work crew (sometimes multiple languages and / or verbal translation may be needed).
  - It may be kept as a reference for future similar operations.

4.2 .1.2 .1 JSA Elements

- Job description
- Potential/ Associated Hazards
- Hazard Controls & Emergency/ Contingency Plans
- Safety Equipment Required
- Questions to Check Tenets Compliance
- Stop Work Authority
- Additional comments
- Signature

4.2 .1.3 Permit

A Permit to Work is a written authorization to perform a work within Chevron's operational control and is required whenever work is conducted that may adversely affect health, environment, safety, efficiency, or reliability of associated personnel or an asset.

4.2 .1.3 .1 Different Permits

- General Work Permit – **Blue**
- Hot Work Specialized Permit – **Red**
- Isolation of Hazardous Energy Specialized Permit – **White**
  - Equipment Isolation Checklist
- Confined Space Entry Specialized Permit – **Green**
- Excavation Specialized Permit – **Brown**
  - Trenching Safety Checklist
- Other SWP Checklists
  - Critical Protection Bypass Register
  - Work at Height Review Checklist Tool

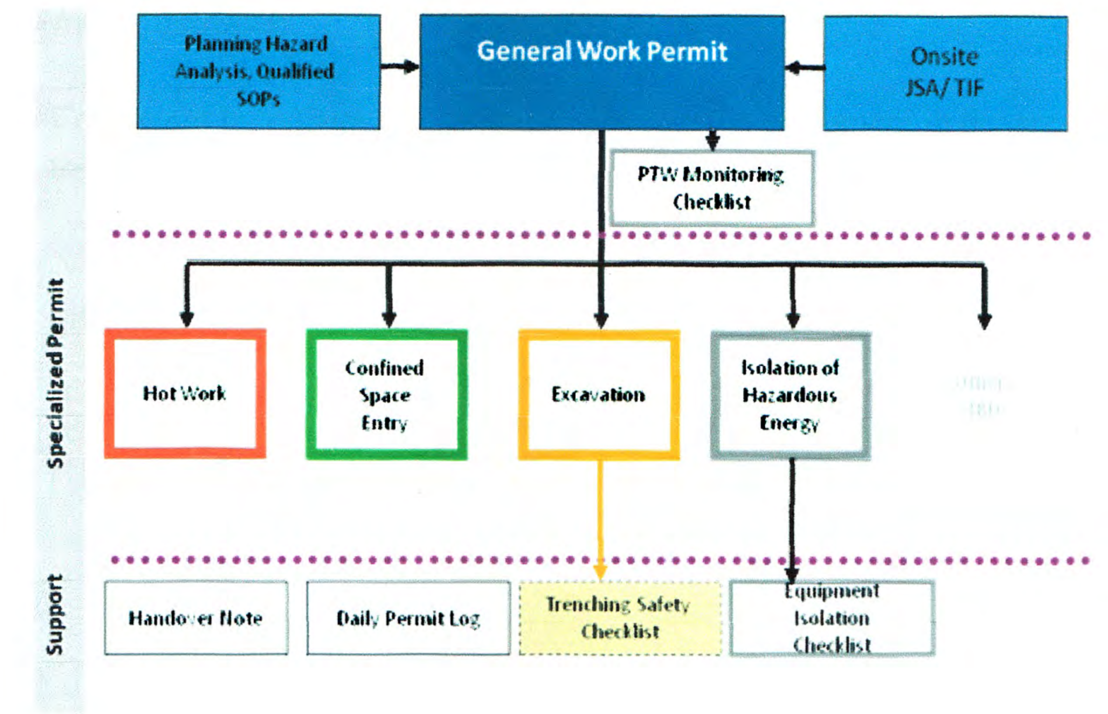


Figure 4.3 Different required Permits

4.2 .1.3 .2 Roles of different responsible person of Permit

- Permit User:

  Individuals performing the work scope defined in the permit.

- Permit Approver:

  Competent individual who has been trained and authorized by the company to review, where applicable sign and approve relevant forms.

- Work Team Leader:

  Person in charge of the work: Competent individual who is responsible for the safe execution of work. The role of the designated leader may vary among several people, depending on the work specified.

- Area Controller:

  Competent individual who is responsible for the equipment in the area where the work is to be performed.

- Site Checker:

  A competent individual who is assigned responsibility to verify work-site activities are in compliance with permit conditions during normal activities [15].

CHAPTER FIVE

INCIDENT INVESTIGATION & REPORTING (IIR)

5.1 A Case Study

All incidents, whether a near miss or an actual injury-related event, should be investigated and reported. Incident investigations are a tool for uncovering hazards that either were missed earlier or have managed to slip out of the controls planned for them. The objective is to identify the root causes, not to primarily set blame. An incident of Chevron Bangladesh Limited in 2012 is elaborated as for example.

5.1.1 Incident

Fire alarm was activated in BY SCR while dismantling false-ceiling.

Management Sponsor: Daniel Oracheski

Incident date: 07 Jan 2012

Incident Description: Fire-water sprinkler and fire alarm was activated in BY SCR at around 11:20 am on 07 Jan 2012 while contractor crew unscrew a sprinkler to dismantle false-ceiling. Mustering was done. No person was injured but water was spread all over the floor.

Figure 5.1 Picture of the Incident

5.1.2 Protective systems that worked and did not worked

Protective System that worked	Protective System didn't work
Fire Alarm System	Planning phase Hazard Analysis (HA)
Emergency Response Plan	Onsite Job Safety Analysis (JSA)
Incident Reporting	Bypassing Critical Protection (BCP)
	Supervision
	MSW Trainings/competencies for Area Controller and Work Team Leader

5.1.3 Root Causes

No.	RC Category	Explanation
RC-1	Training and competency	Training on BCP and IHE Standards for the Work Team Leader and Area Controller was less than adequate
RC-2		Competency of the Area Controller and the Team Leader was less than adequate.
RC-3	Supervision	Supervision of the job was less than adequate.
RC-4	Hazard Analysis	Quality of the planning phase HA and onsite JSA was less than adequate.

5.1.4 Action Items:

- Develop a MSW training matrix for the work team leaders and area controllers involved in FE Construction Projects and organize training sessions as appropriate (in progress).
- Prepare an approved list of Work Team Leaders and Area Controllers for FE Construction Project considering their competencies and training. Also ensure that only personnel from that list are being engaged in the permitted jobs (in progress).

- PIC of the FE Construction Projects to send an email to all concerned personnel (such as, Civil Supervisors, Contractors' Representatives, etc.) stating the importance of planning phase HA and onsite JSA. The email should also highlight that the job site has to be visited prior to developing the HA and it has to be reviewed by HES Personnel. Separate “onsite” JSA has to be conducted and documented for each job location (in progress).

5.1.5 Lesson Learning Sharing on:

- Emergency Stand Down Meeting
- Toolbox Meeting
- Bi-weekly HES Meeting [15].

CHAPTER SIX

OBSERVATION ANALYSIS & INITIATIVES

6.1 BBS/HID/Near Miss Analysis

It has been analyzed one year data of Behavior Based Safety, Hazard Identification and Near Miss of Chevron Bangladesh Limited. From the figure 6.1, it can be noticed that Equipment defect/Maintenance is the most prominent category and Spill/Leakage is the least one. If we summarize this figure, it can be said that it is a negatively decreasing trend. The highest category remains at 70-80 range and the lowest one category remains at 0-10 range. From Equipment defect/Maintenance up to Design are prominent categories. From Electrical to Biological categories are medium and from Environmental up to Spill/Leakage categories are least ones.

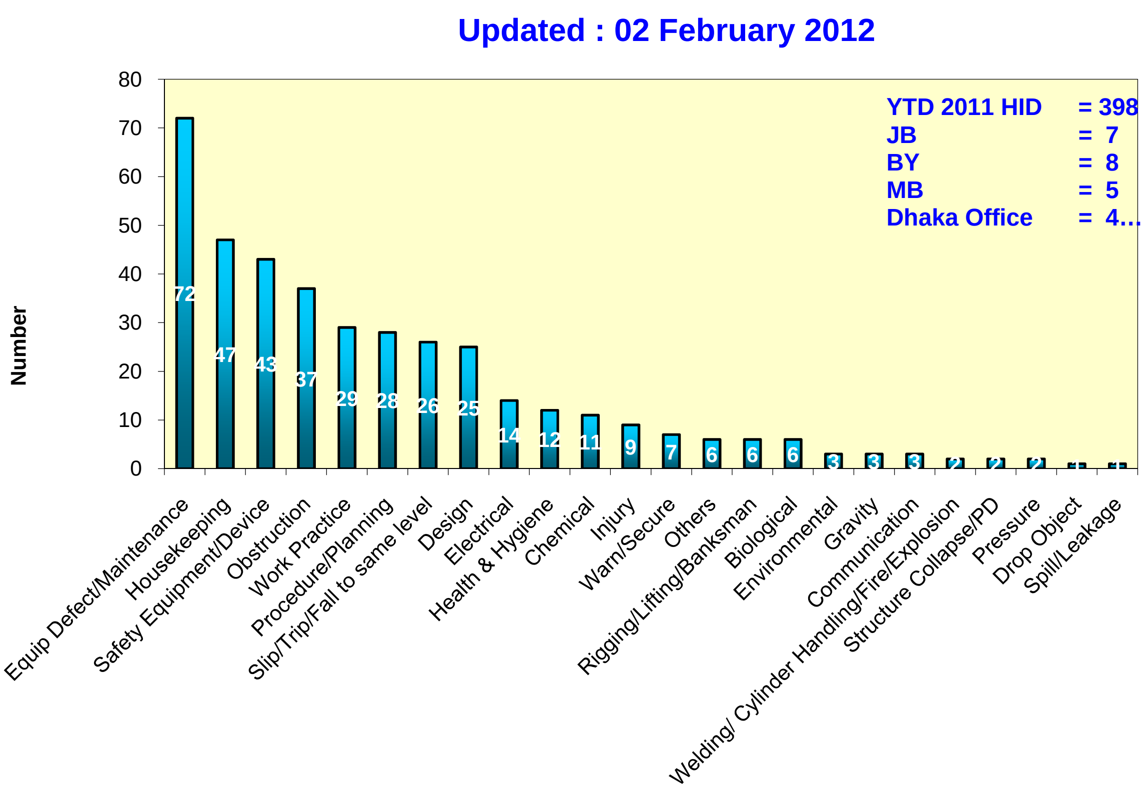


Figure 6.1 BBS/HID/Near Miss Analysis

6.2 Hazard Hunt Campaign

- Hierarchy of Controls:
    a) Remove the energy source.
    b) Prevent the release of energy.
    c) Protect from the release.
    d) Use Stop Work Authority.

- What is a Hazard

A condition or action that has the potential for an unplanned release of, or unwanted contact with an energy source that may result in harm or injury to people, property or the environment.

- Purpose:
    e) Increase awareness of Energy Sources that present Hazards in the workplace.
    f) Identify & eliminate Hazards through a focused Hazard Hunt.
    g) Immediately address the imminent hazards.
    h) Communicate to your Supervisor, the Hazard Hunt findings and actions taken to address any identified Hazards.
    i) Complete the HID Form (summary of the Hazard Hunt findings, actions taken, and any photographs) and submit to HES.
    j) HES dept. will be selecting 2 best HazID forms from each location every month and will recognize individuals.

6.3 Safety Triangle

Safety triangle is a special safety parameter approaching to minimize incidents. Specially for Chevron Bangladesh Limited, the safety triangle starts from Behavior Based Safety Observations up to Fatalities. So many near misses led to lesser number of first-aid injuries and thence onward through the logic recordable injuries and ending in the inevitability of a fatality. From the figure 6.2, it can be mentioned that it has to be taken action up to under the “take action here” line. Beyond this line, nothing can be done if any incident happens. It has to be increased the number of Behavior Based Safety Observations, Stop Work Authority, Hazard Identifications to minimize from the near miss up to fatalities.

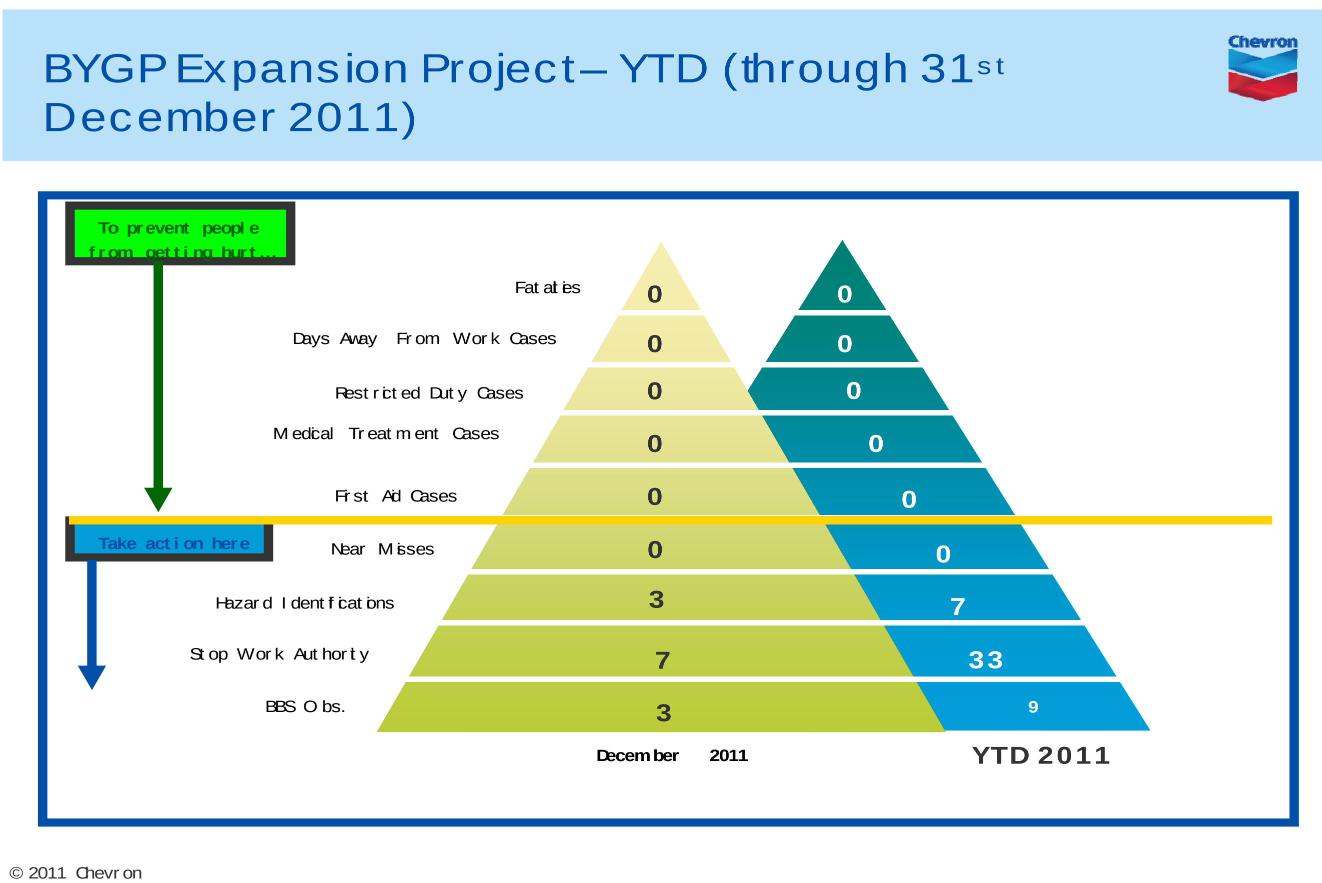
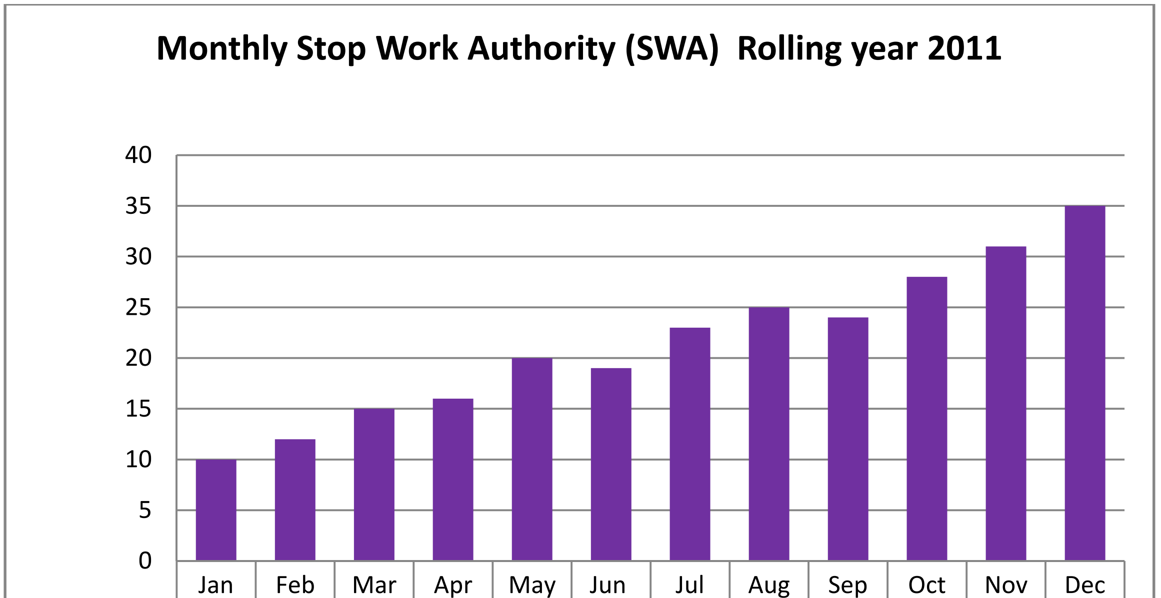


Figure 6.2 Safety Triangle

6.4 HES Data Recording

It has been compiled one year HES data recording of Chevron Bangladesh Limited in the year of 2011. From the figure 6.3, it can be noted that the monthly stop work authority trend had been increasing gradually from 10 to 40. It is obviously an improving trend positively. This HES data recording had been collected from the department of Health, Environment and Safety of Chevron Bangladesh Limited.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number	10	12	15	16	20	19	23	25	24	28	31	35

Figure 6.3 SWA Record

6.5 HES Target

Every company specially in oil and gas sector has an health, environment and safety target which is called HES target. Chevron is committed to helping its employees and contractors remain safe and healthy maintaining a safety target. All work carries risks. However, this company identifies and manages their risks by using their Operational Excellence Management System enhancing their technologies, tools and competency at all levels. They set stringent safety policies, consistently train their workforce and everybody work together to maintain HES target.

Below is the 2011 HES Target:

DAFW - 0.036

TRIR - 0.23

Spill - 2.04

MVCR - 0.05

DAFWR = # DAFW Inc. X 200,000 / Hours Worked

TRIR = (# Fatality Incident + DAFW Incident + # Restricted Duty Incident + # Medical Incident, other than first aid) X 200,000 / Hours Worked

Note that both TRIR and DAFWR are the measure of the rate of workplace injuries, normalized per 100 workers per year. The factor is derived by multiplying the number of recordable injuries in a calendar year by 200,000 (100 employees working 2,000 hours per year) [8 hours per day, 5 days a week, 50 weeks per year] and dividing this value by the total man-hours actually worked in the year [15].

CHAPTER SEVEN

DATA ANALYSIS AND FINDINGS

7.1 Statistical Analysis

Statistical analysis is a component of data analytics. In the context of business intelligence, statistical analysis involves collecting and scrutinizing every single data sample in a set of items from which sample can be drawn. The goal of statistical analysis is to identify trends. A retail business, for example, might use statistical analysis to find patterns in unstructured and semi-structured customer data that can be used to create a more positive customer experience and increase sales. Statistical analysis describes the nature of the data to be analyzed and explore the relation of the data to the underlying population. Also it proves the validity of the model and employs predictive analytics to run scenarios that will help guide future actions.

7.1 .1 Simple Linear Regression Model

In regression analysis, as in other types of statistical studies, we usually proceed by observing the sample data and using the results obtained as the estimates of the corresponding population relationship. To make valid inferences, we must assume some population model. The particular one in which we are interested is called the simple linear regression model. This model is constructed under the following set of assumptions:

i) The value of the dependent variable, Y, is dependent in some degree upon the value of the independent variable, X. the dependent variable is assumed to be a random variable, but the value of X are assumed to be fixed quantities that are selected and controlled by the experimenter.
ii) The average relationship between X and Y can be adequately described by a linear equation $Y = a + bX$ whose geometrical presentation is a straight line as in the diagram as follows:

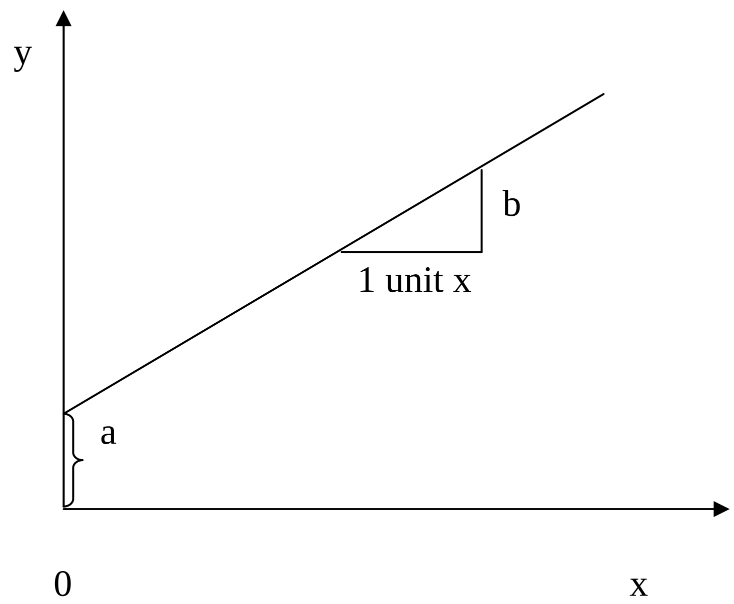


Figure 7.1 Linear Regression

As is clear from the above diagram, the height of the line tells the average value of Y at a fixed value of X. when X =0, the average value of Y = a. The value of a is called the Y intercept, since it is the point at which the straight line crosses the Y- axis. The slope of the line is measured by b, which gives the average amount of change of Y per unit change of X. The sign of b also indicates the type of relationship between Y and X.

7.1 .1.1 Regression Lines

If we take the case of two variables X and Y, we shall have two regression lines as the regression line of X on Y and the regression line of Y on X. The regression line of Y on X gives the most probable values of Y for given values of X and the regression line of X on Y gives the most probable values of X for given values of Y. However, when there is either perfect positive or perfect negative correlation between the two variables, the two regression lines will coincide, i.e., we will have one line.

7.1.1.2 Regression Equations

Regression equations are algebraic expressions of the regression lines. Since there are two regression lines, there are two regression equations- the regression equation of X on Y is used to describe the variations in the values of X for given changes in Y and the regression equation of Y on X is used to describe the variations in the values of Y for given changes in X.

7.1.1.3 Regression Equation of Y on X

The regression equation of Y on X is expressed as follows:

$$Y_e = a + bX$$

Where Y_e is the dependent variable to be estimated and X is the independent variable.

In this equation a and b are unknown constant(fixed numerical values) which determine the position of the line completely. The constants are called the parameters of the line. If the value of either or both of them is changed, another line is determined. The parameter ‘a’ the level of the fitted line (i.e., the distance of the line directly above or below the origin). The parameter ‘b’ determines the slope of the line, i.e., the change in Y for unit change in X.

If the values of constants ‘a’ and ‘b’ are obtained, the line is completely determined. But the question is how to obtain these values. The answer is provided by the method of least squares which states that the line should be drawn through the plotted points in such a manner that the sum of the squares of the vertical deviations of the actual Y values from the estimated Y values is the least, or, in other words, in order to obtain a line which fits the points best, $\sum(Y-Y_e)^2$ should be minimum*. Such a line is known as the line of best fit.

With a little algebra and differential calculus, it can be shown that the following two equations, if solved simultaneously, will yield values of the parameters a and b such that the least squares requirement is fulfilled.

$$\sum Y = Na + b\sum X \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (i)$$

$$\sum XY = a\sum X + b\sum X^2 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (ii)$$

These equations are usually called the normal equations. In the equations $\sum \mathbf{X}$, $\sum \mathbf{Y}$, $\sum \mathbf{XY}$, $\sum \mathbf{X^2}$ indicate totals which are computed from the observed pairs of values of two variables X and Y to which the least squares estimating line to be fitted and N is the total number of observed pairs of values.

7.1.1.4 Regression Equation of X on Y

The regression equation of X on Y is expressed as follows:

$$X_e = a + bY$$

To determine the values of a and b the following two normal equations are to be solved simultaneously.

$$\sum X = Na + b\sum Y \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (i)$$

$$\sum XY = a\sum Y + b\sum Y^2 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (ii)$$

$\sum(Y-Y_e)^2$ should be minimum.

Let, $S = \sum(Y-Y_e)^2$

Or, $S = \sum(Y-a-bX)^2$; [Since, $Y_e=a+bX$]

Differentiating partially with respect to a and b,

$$\partial S/\partial a = \sum(Y-a-bX)(-1) = 0$$

$$\partial S/\partial a = \sum(Y-a-bX)(-X) = 0$$

Or, $\sum(Y\text{-}a\text{-}bX) = 0$

$\sum(Y\text{-}a\text{-}bX)X = 0$

Or, $\sum Y=Na + b\sum X$

$\sum XY = a\sum X + b\sum X^2$

Here, the coefficient a and b are given by,

$a = (\sum Y – b \sum X) / N$ **and**

$b = [N\sum XY\text{-} (\sum X) (\sum Y)]/ [N(\sum X^2) –(\sum X)^2]$ [16].

7.1 .2 Multiple Linear Regression Model

Multiple linear regression attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data. Every value of the independent variable *x* is associated with a value of the dependent variable *y*. The population regression line for *p* explanatory variables $x_1, x_2, \ldots, x_p$ is defined to be $\mu_y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p$. This line describes how the mean response μ_y changes with the explanatory variables. The observed values for *y* vary about their means μ_y and are assumed to have the same standard deviation σ. The fitted values $b_0, b_1, \ldots, b_p$ estimate the parameters $\beta_0, \beta_1, \ldots, \beta_p$ of the population regression line.

Since the observed values for *y* vary about their means μ_y, the multiple regression model includes a term for this variation. In words, the model is expressed as DATA = FIT + RESIDUAL, where the "FIT" term represents the expression $\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots \beta_p x_p$. The "RESIDUAL" term represents the deviations of the observed values *y* from their means μ_y, which are normally distributed with mean 0 and variance σ. The notation for the model deviations is ε.

Formally, the model for multiple linear regression, given *n* observations, is

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots \beta_p x_{ip} + \varepsilon_i \text{ for } i = 1,2, \ldots n.$$

In the least-squares model, the best-fitting line for the observed data is calculated by minimizing the sum of the squares of the vertical deviations from each data point to the line (if a point lies on the fitted line exactly, then its vertical deviation is 0). Because the deviations are first squared, then summed, there are no cancellations between positive and negative values. The least-squares estimates $b_0, b_1, \ldots b_p$ are usually computed by statistical software.

The values fit by the equation $b_0 + b_1x_{i1} + ... + b_px_{ip}$ are denoted $\hat{y}_i$, and the residuals e_i are equal to $y_i - \hat{y}_i$, the difference between the observed and fitted values. The sum of the residuals is equal to zero.

The variance σ^2 may be estimated by $s^2 = \frac{\sum e_i^2}{n-p-1}$, also known as the mean-squared error (or MSE). The estimate of the standard error s is the square root of the MSE.

7.2 HES Data of Chevron Projects

We have analyzed Health, Environment and Safety Data of different projects of Chevron Bangladesh Limited in the year 2011. We have collected data of six projects from the Health, Environment and Safety department of Chevron Bangladesh Limited and the name of the projects are BY Fencing, BY-South West, BY-South South, Pipeline (MB-9), Pipeline (MB-7), North Pad Drill. The unit we used in our analysis is thousand man-hours for safety interventions and number of incidents per two hundred thousand hours in a year.

7.2 .1 Safety Intervention Elements (Chevron)

Twenty three safety intervention elements of Chevron Bangladesh Limited are analyzed at our consideration which is listed below:

1. Auditing
2. Communication
3. Contractor Safety
4. Design
5. Emergency Response
6. Human Factor
7. Incident Investigation
8. Inspection/Quality Control
9. Management of Change

10. Natural Phenomena
11. Pre- start-up Safety Review
12. Preventive maintenance/Repeat failure
13. Procedure & Safe work Practices
14. Risk Management
15. Supervision
16. Training & Competency
17. Leadership and Accountability
18. Qualification Selection and Pre-Job
19. Employee Engagement and Planning
20. Work in Progress
21. Evaluation, Measurement and Verification
22. Safety awareness and motivation activities
23. New tools and equipment design methods and activities

7.2 .2 The impact of safety resource/budget increasing on incident rate reduction

This is to be analyzed by a mathematical analysis and represented by a graphical presentation.

The governing equation of the form:

$$Y = \alpha_1 + \alpha_2 \exp(-x)$$

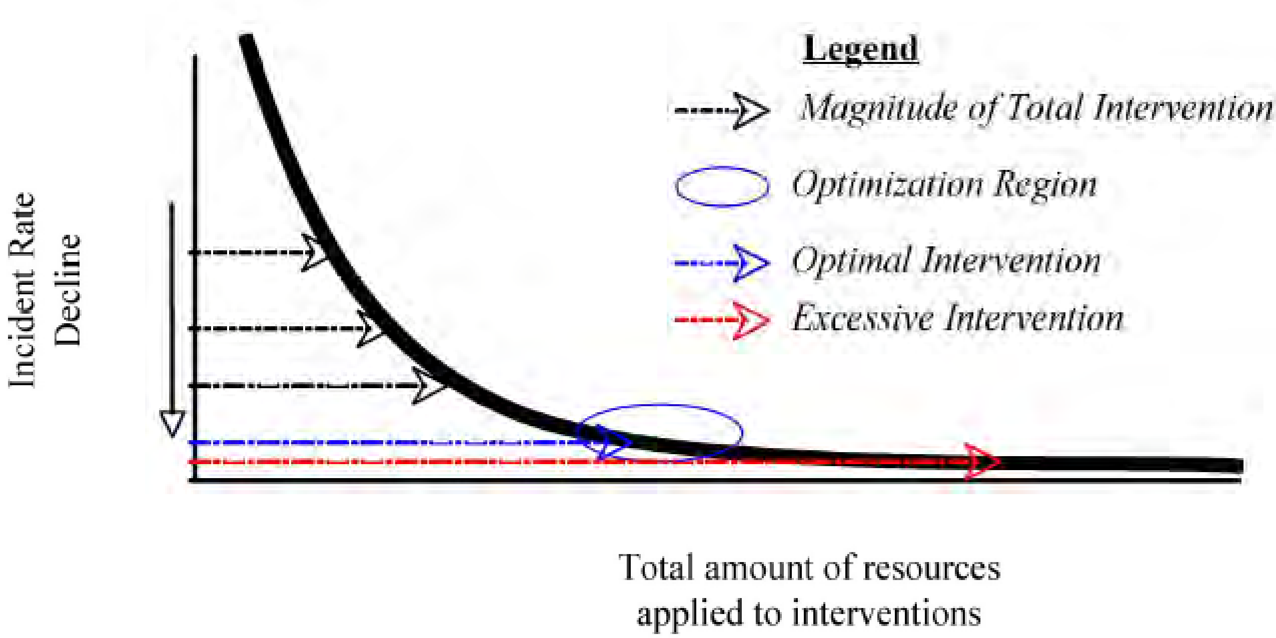


Figure 7.2 Exponential Decay for Incident Rate.

This research therefore, goes a step further in identifying the region at which any additional allocation of man-hours will no longer provide a realistic justification for continuous allocation of resources. It should be noted that additional application of resources in an effort to further minimize incident rate beyond the "optimum region" will lead to an unnecessary increase in safety costs. Although, most companies may be willing to allocate huge resources and capital towards achieving incident rates of zero, it may be highly impossible to achieve this objective in reality. The exponential curve which depicts exponentially decaying relationship between incident rate and total man-hours applied to safety intervention activities is shown in Figure 7.2.1.

Table 7.1 Pareto Chart

Pareto Chart				
Sl.	Category	Count	% of Total	Cumlative Percent
1	Leadership and Accountability	118	17.6	17.6
2	Qualification Selection and Pre-Job	111	16.5	34.1
3	Employee Engagement and Planning	98	14.6	48.7
4	Work in Progress	80	11.9	60.6
5	Evaluation, Measurement and Verification	67	10	70.6
6	Human Factor	33	4.9	75.5
7	Incident Investigation	25	3.7	79.2
8	Inspection/Quality Control	19	2.8	82
9	Management of Change	15	2.2	84.2
10	Natural Phenomena	14	2.1	86.3
11	Pre- start-up Safety Review	13	1.9	88.2
12	Preventive maintenance/Repeat failure	12	1.8	90
13	Procedure & Safe work Practices	11	1.6	91.6
14	Risk Management	10	1.5	93.1
15	Supervision	9	1.3	94.4
16	Training & Competency	8	1.2	95.6
17	Auditing	7	1	96.6
18	Communication	6	0.9	97.5
19	Contractor Safety	5	0.7	98.2
20	Design	4	0.6	98.8
21	Emergency Response	3	0.4	99.2
22	Safety awareness and motivation activities	2	0.3	99.5
23	New tools and equipment design methods and activities	1	0.1	100
	TOTALS	671	100	100

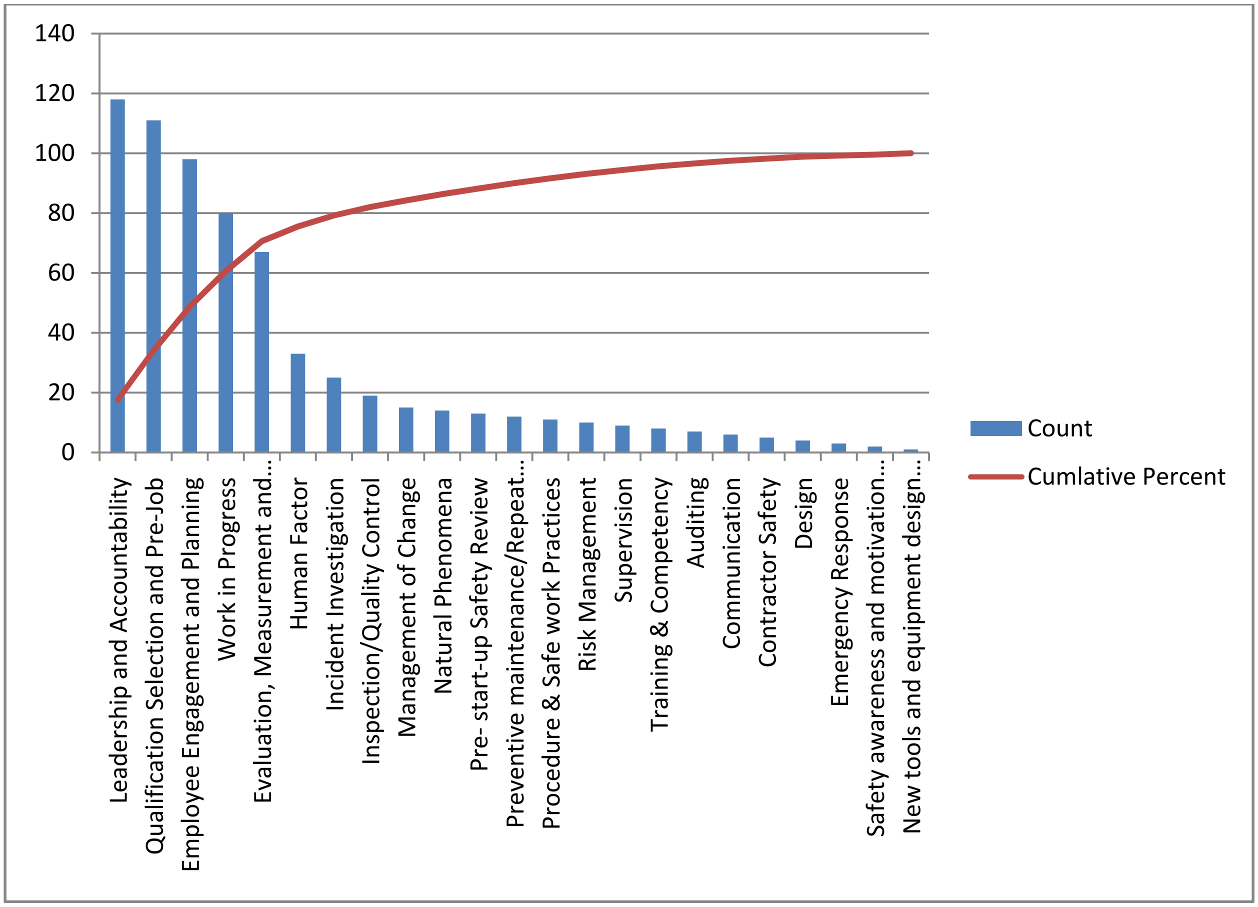


Figure 7.3 Pareto Chart

7.2 .3 Five prominent safety interventions

Numerous studies have proposed multiple variables or factors which are important in the development of successful safety intervention programs. In order to effectively document and organize the collected data, a weekly data sheet was used to record man-hours allocated to the various intervention activities. The thirty-four safety activities selected for this research work are based on the health, environment and safety management information of the organization. Five prominent safety interventions selected from the above Pareto Chart listed below:

7.2.3.1 Factor A: Leadership and Accountability

1. Process sponsor engagement in employee health, environmental and safety management
2. Process advisor engagement in employee health, environmental and safety management
3. Organizational targets are established for performance indicators
4. The company leadership periodically reviews employee health, environmental and safety (HES) performance, recommends and implements improvement
5. The company leaders and managers establish, provide resources and participate in employee health, environmental and safety management

7.2.3.2 Factor B: Qualification Selection and Pre-Job

1. An approved employee lists are maintained
2. The employee qualification and selection process addresses HES performance considerations
3. Employees apply HES requirements to contractors or third parties
4. Pre-Job meetings with employees are conducted prior to start of work
5. A Pre-Job “HES plan” is developed for all work projects
6. Identification, supervision, training and management of short service employee
7. A motivational/safety incentive for the employees is in place

7.2.3.3 Factor C: Employee Engagement and Planning

1. Local Tenets of operational excellence (OE) are communicated to employees and incorporated into employee work process
2. Periodic meetings between company leadership and employee representatives are conducted.
3. Joint employees-contractor meetings are held

4. Regular field visits are conducted by company managers and supervisors for the
5. purpose of discussing HES performance with employees
6. Specific local strategies and plans are developed and implemented to improve local employee HES performance
7. An employee safety plan that addresses all risk assessment is in place.
8. HES expectations and requirements are clearly communicated to the employee and contractor prior to contract execution

7.2.3.4 Factor D: Work in Progress

1. Incident investigation and review (II&R) process
2. Employee health, environmental and safety management process audits and evaluates safety performances periodically
3. Daily tailgate and regular HES meetings are conducted
4. Job safety analysis (JSA) are conducted
5. Pre-task hazard assessments are conducted by the employee and contract crew
6. On- site HES monitoring is provided for high risk and or large jobs
7. Field reviews are conducted
8. Management reviews conducted joint on employees and contractors

7.2.3.5 Factor E: Evaluation, Measurement and Verification

1. Joint post job evaluations are conducted part of evaluation
2. Results communicated to contractors
3. Lessons learned are evaluated and incorporated into future contracting efforts [17].

7.3 Mathematical Safety Model

The percentage of each of these five factors to the total available man-hours corresponds to $x1$, $x2$, $x3$, $x4$ and $x5$ where $x1$, $x2$, $x3$, $x4$ and $x5$ are regarded as the independent variables. The dependent variable is the total incident rate recorded per 200,000 hour which is denoted with y. Based on this, a mathematical representation is expressed for the interactive relationship between the independent and dependent variables is shown in equation 1.

$y = f(x1, x2, x3, x4, x5, \_)$………. (1)

From the above representation, _ denotes the human and process error in the intervention which includes the uncontrollable and nuisance factors. The input variables or controllable factors, *x1,…, x5* are represented as:

Table 7.2 List of input variables, factors and safety intervention activities

Input variables	Factor	Safety intervention activity
X_1	A	Leadership and accountability
X_2	B	Qualification, selection and pre-job
X_3	C	Contractor engagement and planning
X_4	D	Work in progress
X_5	E	Safety evaluation, measurement

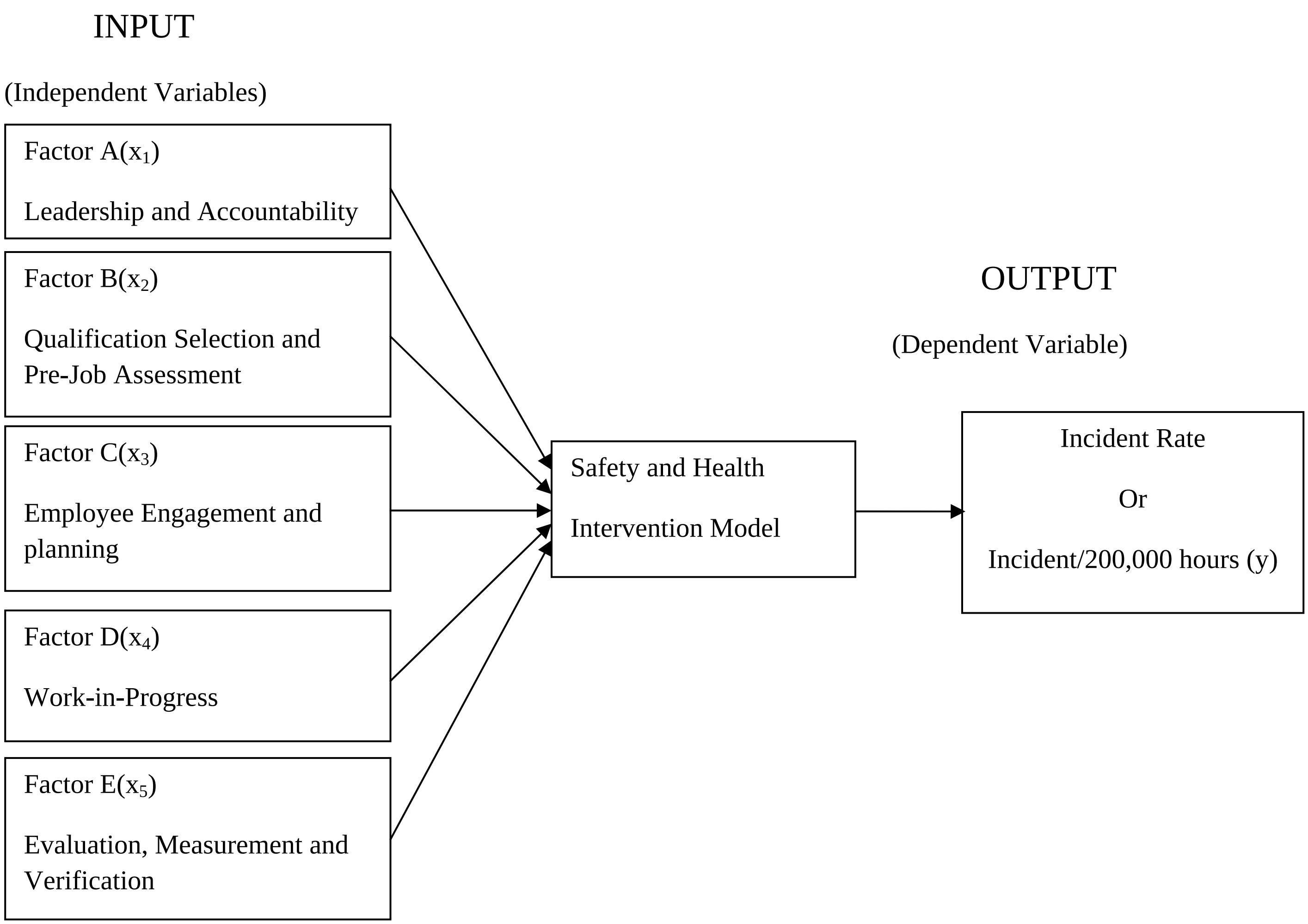


Figure 7.4 Representation of the safety intervention model

7.4 Safety Statistics

We used one year safety statistics data of Chevron Bangladesh Limited which is a leading multinational company of oil and gas sector in Bangladesh. Here it is included Projects Man-Hour (Actual) data in thousand hours, Projects HES Tools Applied (Thousand Hours), Lost Time Incidents in Implementation Stages and lastly Consequences in the terms of all type of reportable and recordable incidents. It is the safety statistics data of Chevron Bangladesh Limited occurred in 2011.

Table 7.3 Projects Man-Hour (Actual)

Year 2011	Projects Man-Hour(Thousand Hour)						
	Actual						
	Projects						Monthly Total
	BY-Fencing	BY-South West	BY-South South	Pipeline (MB-9)	Pipeline (MB-7)	North Pad Drill	
Jan	20	28	16	14	17	23	118
Feb	19	26	21	16	19	24	125
Mar	22	31	32	21	22	24	152
Apr	22	18	30	23	18	26	137
May	21	28	31	25	19	25	149
Jun	18	29	33	28	20	22	150
Jul	15	20	28	25	21	21	130
Aug	21	26	26	22	22	23	140
Sep	22	26	29	26	16	25	144
Oct	21	21	32	25	16	24	139
Nov	17	13	30	19	15	24	118
Dec	16	15	24	20	13	25	113
Yearly Total	234	281	332	264	218	286	1615

Table 7.4 HES Tools Applied

Sl.	Year 2011	Projects HES Tools Applied(Thousand Hours)					
		Actual					
		Projects					
		A	B	C	D	E	Total
1	Jan	6	3	0	5	5	19
2	Feb	4	4	3	4	4	19
3	Mar	4	2	4	3	3	16
4	Apr	0	4	2	0	9	15
5	May	4	5	2	3	4	18
6	Jun	3	0	4	8	5	20
7	Jul	5	8	3	6	8	30
8	Aug	4	7	0	4	0	15
9	Sep	7	4	5	3	4	23
10	Oct	0	3	0	9	5	17
11	Nov	3	0	7	7	6	23
12	Dec	4	5	6	6	0	21
Yearly Total		44	45	36	58	53	236

7.4.1 Lost Time Incidents

Lost time incident is when an employee gets injured while carrying out a piece of work for the employer and is unable for perform the regular duties for a complete shift. From the time of incident till the time the employee join back the duties, the time lost is the "lost time incident. By regular duties it is meant those duties that are defined in the job description of the employee.

Table 7.5 Implementation Stages

Year 2011		Reportable safety issue /Safety Observation		Total
	Man-hour	Behavior Based Safety	Hazard Identification	
	Exp.Hours (Thousand)	BBS	HID	(HID +BBS)
Jan	19	1456	304	1760
Feb	19	1689	379	2068
Mar	16	2007	485	2492
Apr	15	2380	538	2918
May	18	2597	653	3250
Jun	20	2679	709	3388
Jul	30	1598	382	1980
Aug	15	1762	436	2198
Sep	23	1908	554	2462
Oct	17	1678	412	2090
Nov	23	2439	658	3097
Dec	21	1547	306	1853

Table 7.6 Consequences

Year 2011	Reportable safety issue/Incidents		Recordable/No. Lost Time Incidents.				Total
	Near Miss	No. of First Aid Cases	No. of Medical Treatment Cases	No. of Days Away from Work Cases	No. of Restricted Duty Cases	No. of Fatalities	
Month	NM	FAC	MTC	DAFW	RDC	FAT	(MTC+DAFW +RDC+FAT)
Jan	144	16	4	3	1	0	8
Feb	136	15	3	2	0	0	5
Mar	124	19	4	1	0	0	5
Apr	98	16	4	0	0	0	4
May	106	15	3	2	1	0	6
Jun	123	12	4	2	0	0	6
Jul	69	19	2	3	0	0	5
Aug	75	13	2	2	0	0	4
Sep	89	16	3	0	0	0	3
Oct	78	10	3	3	0	0	6
Nov	96	15	3	1	0	0	4
Dec	56	10	2	2	0	0	4

CHAPTER EIGHT

RESULTS AND DISCUSSION

8.1 MINITAB

Minitab software gives us the confidence we need to improve quality, with features like an interactive assistant that guides us through our analysis. It is specially designed to help us to succeed at every step of our statistical analysis. Once we have chosen the right tool, the Minitab software identifies all the steps we should take to ensure the results of our analysis are accurate and trustworthy. We used this Minitab software at our analysis to correlate safety interventions and lost time incidents in a perfect condition.

Table 8.1 Safety Interventions and Lost Time Incidents

Year 2011	Safety Interventions					Total No. Lost Time Incidents. (MTC+DAFW+RDC+FAT)
Month	X1	X2	X3	X4	X5	Y
Jan	6	3	0	5	5	8
Feb	4	4	3	4	4	5
Mar	4	2	4	3	3	5
Apr	0	4	2	0	9	4
May	4	5	2	3	4	6
Jun	3	0	4	8	5	6
Jul	5	8	3	6	8	5
Aug	4	7	0	4	0	4
Sep	7	4	5	3	4	3
Oct	0	3	0	9	5	6
Nov	3	0	7	7	6	4
Dec	4	5	6	6	0	4

General Regression Analysis: Y versus X1, X2, X3, X4, X5

Regression Equation

Y = 17.9834 + 1.18116 X1 - 1.16739 X2 - 1.62623 X3 - 0.681564 X4 + 0.393113 X5

Coefficients

Term	Coef	SE Coef	T	P
Constant	17.9834	6.02320	2.98569	0.024
X1	1.1812	0.68539	1.72334	0.136
X2	-1.1674	0.61537	-1.89704	0.107
X3	-1.6262	0.60529	-2.68671	0.036
X4	-0.6816	0.52639	-1.29478	0.243
X5	0.3931	0.49780	0.78970	0.460

Summary of Model

S = 4.11368 R-Sq = 64.12% R-Sq(adj) = 34.22%
PRESS = 429.229 R-Sq(pred) = -51.67%

Analysis of Variance

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	5	181.466	181.466	36.293	2.14469	0.0190020
X1	1	7.736	50.258	50.258	2.96989	0.0135598
X2	1	5.222	60.900	60.900	3.59877	0.0106606
X3	1	122.163	122.153	122.153	7.21842	0.0036211
X4	1	35.792	28.370	28.370	1.67645	0.0242987
X5	1	10.553	10.553	10.553	0.62363	0.0459763
Error	6	101.534	101.534	16.922		
Total	11	283.000				

Fits and Diagnostics tested for Unusual Observations and there is no unusual observations found.

The safety model is significant, as the P value is equal or smaller than 0.05 (for 95%).

8.2 Best safety tools pairs (Response Surface Plot)

The response surface designs depicting the relationship between incident rate and Factors A, and E represents in the figure 8.1. It should be noted that incident rate is minimized in the depressed region of the response surface plots (local minimum) while the elevated point depicts the region of increased incident rates (local maximum).

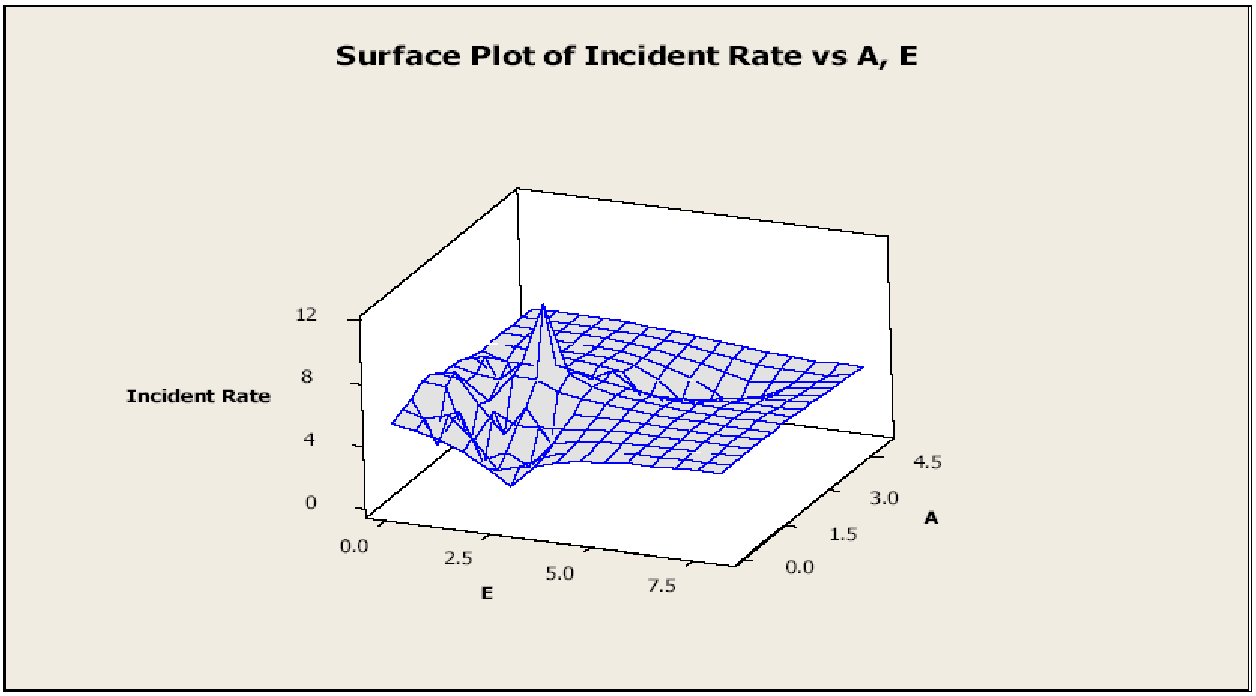


Figure 8.1 Response Surface Plots of Incident Rate vs. Factor A and E.

The optimum or desirable incident rate (zero) is achieved when the organization allocates 1.5% of its available man-hours or resources to Factor A (Leadership and Accountability) and 2.5% of its available man-hours or resources to Factor E (Evaluation, Measurement and Verification). On the other hand, incident rate is drastically increased (a value of 12) when the organization doubles the allocation of its available man-hours or resources from 1.5% to 3.0% to Factor A, but the allocation of the available man-hours or resources to Factor E is kept the same at 2.5%. This indicates that the additional allocation of resources towards safety intervention activities do not necessarily minimize incident rates.

CHAPTER NINE

CONCLUSION AND RECOMMENDATION

9.1 Conclusion

As a country of great future energy prospects, Bangladesh should have to take effective and efficient measure for conducting systematic (Safe) exploration activity in the country. It can easily be said that we have not been acted according to our vast energy resources because there still remain a large amount of reserve for petroleum resources of Bangladesh. As the same time one cannot loose sight of the fact that exploration is ‘high capital intensive’ and risky venture. It should be remembered that the energy resources that we have, is far more capable of uplifting the energy status and overall the economic status of the country if proper action to explore and distribute are taken in time.

The analysis obtained from this research work could be used to develop an effective resource allocation program which would minimize costs associated with safety. Mathematical modeling of intervention activities provides the opportunity for efficient management of the safety system based on the developed resource allocation methodology. Industrial incident-associated costs, such as compensation, down time costs are reduced in situations where an organization is aware of the various safety intervention factors needed to reduce incident rates. Increased workplace safety improves the level of image preservation and reputation of a safety-conscious organization. This in turns reduces employee turnover rate, increases profitability and improves the public shareholder value.

This research study shows that the additional allocation of resources towards safety intervention activities do not necessarily minimize incident rates (See Figure 8.1). Also, the allocation of resources to Factor B (Qualification, Selection and Pre-Job) would not likely improve the safety intervention program, thereby leading to indiscriminate waste of resources and capital. This means that the qualifications of the employees do not impact safety activities within the organization examined. The types of selection methods for tasks, as well as other safety activities such as the implementation of incentive programs and individual safety training do not necessarily minimize incident rates.

9.2 Recommendation

We intend to further expand this work by verifying the developed model based on the recommendations from this work. Using optimization techniques, the developed safety intervention model would be able to predict incident rate values based on these input variables (factors). A critical step in the expansion of this work is to set safety decision making standards by incorporating weights to the factors. This is intended to provide a more realistic value of incident rates and could indicate the level of willingness of the management in the allocation of resources towards the safety activities. The weighted safety model would incorporate quantitative techniques and the preference of the management based on past incident rates to predict effective resource allocation policies which will minimize ineffective intervention programs.

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