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Safety, Health and its Relation to Reliability in Oil and Gas Industry

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ABSTRACT: *Accident and incident occurrences have led to loss of invaluable cost in the oil and gas industry. Accidents or incidents however don"t just occur but are caused by preceding events. This project clearly outlines the principals involved in accident/ incident investigation, critically reviews the techniques used in root cause analysis in order to identify their strengths and weaknesses, provides a detailed knowledge of the key phases employed in root cause analysis and develops recommendations for improvement and generation of implementation of root cause analysis report. On conclusion of this thesis through recommendations developed, lives will be saved by providing a safe and healthy working environment for personnel and the public in general, down time minimized,huge cost saved through adequate maintenance of facilities/ equipment, minimal or negligible insurance claims etc. This will thus ensure safety, health and reliability in the vibrant oil and gas industry. Despite having a standard training program, the level of competency to investigate accidents and incidents adequately and comprehensively vary from one safety professional or investigation team to another. This could be attributed to the number and types of accidents/incidents investigated i.e. experience, the frequency at which theinvestigations are carried out, information and documentation available for assessment, skills etc. Though these factors vary with age, experience, personal ability and industry, certain skills are essentially required for any accident or incident investigation. They include the following;*

- *Careful observation and understanding of key factors at the scene of theincident/accident and other areas of relevance to the occurrence*
- *An understanding of the technical, physical and chemical aspects of theincident/accident as the case may be*
- *Interviewing personnel and witnesses*
- *Taking of appropriate photographs and preparation of adequate sketches*
- *Ability of adequately record all relevant factors for future reference*
- *Evaluations of documentation i.e. work permits, operational manuals, and repairs/maintenance certification etc.*
- *Report writing*
- *The correct interpretation of relevant health and safety laws.*
- *Development of appropriate remedial action to prevent reoccurrence.*

KEYWORDS: safety, health, relation, reliability, oil and gas industry

INTRODUCTION

This research project is initiated with an introduction to incident or accident occurrences in the oil and gas industry which is a high hazard industry due to its operations and processes. The objective of undertaking a root cause analysis of an event which is a key to ensuring an incident reoccurrence is considered. Various techniques used in root cause analysis have been critically reviewed with a view of improving the root cause analysis process. An overview of the incident/accident investigation process will be explained and critical events leading to an incident will be discussed. Key issues such as human error, risk assessment and legislation as it relates to the root cause analysis process will be established. This thesis also identifies the analysis of management levels as a vital element to improving root cause analysis to ensure health and safety in the oil and gas industry

DATA ANALYSIS AND RESEARCH METHODOLOGY

Root cause analysis (RCA) can be defined as a process designed for the investigation and categorisation of the root causes of events which have safety, health, environmental, quality, production and reliability impacts. Root cause analysis (RCA) is a step by step method which leads to the discovery of a fault‟s first or root cause. For an equipment or system to fail, there is a direct progression of actions and consequences leading to the failure. RCA thus aims to identify the basic cause of the accident or incident as the case may be in view of find solution and generating recommendations which will prevent the reoccurrence of similar or avoidable events. It is a tool which enables investigators to determine what, how and why an event occurred. Proper understanding of the foregoing thus helps to prevent the reoccurrence of the same or similar events and also aids management to control root causes by the development and implementation of recommendations made from root cause analysis.

Root cause is the most basic cause that can be reasonably identified and that management has control to fix" (Paradies and Busch, 1988). Four vital elements which are key to a successful RCA can thus be drawn from this definition.

(i) Basic or underlying causes: In order to develop recommendations which will prevent the occurrence of similar events, investigators should aim at identifying the specific reasons as to why an incident occurred.
(ii) Reasonably identified: Due to the cost involved in RCA, investigation must be completed within a defined time frame.
(iii) Control: Root cause analysis must yield specific classification rather than general in order to effect adequate changes.
(iv) Management: Recommendations made from the investigation of root cause analysis should be implemented by the management.

To effectively undertake RCA, the following points must be taken into consideration.
1. Why is it important to determine the root cause?
It is important to distinguish between the primary or root cause and the contributory causes in order to develop the appropriate corrective actions to prevent the problem from reoccurring. If a thorough

investigation of the problematic situation is not undertaken, the corrective actions developed will not eliminate or alleviate the problem and this is waste of valuable resources. The following are types of causes;

A. Presumptive cause(s): These are causes which may not be apparent at the beginning of the investigation or that emerges during the data collection process. They are hypotheses which explain the effects of the problem though they require validation.

B. Contributing cause(s): Causes that alone would not cause a problem but should be considered as requiring corrective action to improve the quality of the process or product.

C. Root causes: Causes that are the most basic reason for a problem which if corrected will prevent reoccurrence and management can fix.

2. When to determine the root cause?
The root cause should be determined after defining the problem. The investigator must plan a strategy and begin to obtain data to test possible causes.

3. How to determine the root cause?
Once the problem has been defined, the investigator needs to plan a strategy for determining the root cause. Organise data, reassess strategy and determine what action would be appropriate to collect additional needed data.
Root cause analysis is a five phase process which involves collection of data, assessment, root cause identification, recommendation generation, RCA reporting and implementation.

• Data Collection: Gathering of data phase of RCA should be done immediately following the occurrence identification as this will provide incident investigators with complete information and understanding of the causal factors and root causes associated with the incident. Information to be collected includes conditions before, during and after the occurrence, environmental factors, personnel involvement and any relevant information to the occurrence.

• Assessment: In carrying out assessments, various RCA methods such as events and causal factor charting, change analysis, barrier analysis, human performance evaluation (HPE) etc can be employed. Which ever method is used however, the aim of the assessment is to identify the problem, determine the significance of the problem, identify the causes i.e. condition and/or actions which immediately precede and surround the problem, identify why the reasons in the preceding steps existed initially.

• Corrective action: Following the identification of root causes for a particular causal factor, achievable recommendation to prevent reoccurrence can be generated. This will improve reliability and safety within the industry.

• Reporting: RCA report should be entered on the Occurrence Reporting and Processing System (ORPS). Investigators should also discuss and explain the findings on the analysis, including corrective measures with management and possibly personnel involved in the occurrence. Information of interest to other facilities should also the given.

• Follow-up and Implementation: An effective review is essential to ensure that corrective actions are implemented and that they practically prevent reoccurrence of similar incidents. The responsibility for the implementation of these recommendations however rest on the management.

The objective of undertaking an investigation and reporting the cause of occurrences is to establish corrective action which will prevent the reoccurrence of such incidents, thus providing a safe and healthy environment for workers and the public while ensuring reliability. The incident investigation process understudies the occurrence, its causes and remedial actions to be adopted to prevent reoccurrence. The basic step in incident investigation involves obtaining a complete description of the sequence of events which led to the incidence. Information such as initial or recurring problems or incidents, events preceding the occurrence, hard/soft wares associated with the occurrence, recent repairs/maintenance, personnel training, management program, physical environment or circumstances etc will enable a successful investigation process. This information can be obtained from interviews with personnel, identifying the conditions and action preceding the incident. Answers to fundamental questions like how did it happen? Why did it happen? Could it have been prevented? Why was this not prevented? Will help identify the root cause of the incident and the most appropriate corrective action to be adopted. A detailed explanation of the phases employed in the incident investigation process is outlined as follows;

Two important part of the accident investigation process is defining the problems and the collection of data. Before collecting data it is important to clearly and specifically identify and describe the problem you are trying to solve in an effort to focus your RCA and corrective action efforts. During your systematic effort to define the problem, you may also realise multiple problems that should be handled separately.
A problem can be simply defined as a deviation from a requirement or expectation i.e. when "actual" is different from "should". It can also be described as an undesirable event, situation or performance trend; and/or the primary effect critical for a situation to occur. This can be identified if you were assigned a problem to solve by the management, observed an event, near miss or a negative trend, told the problem when summoned to join a team etc. The aim of defining the problem is to identify the causes and possible

corrections. It helps the investigation team to understand the solution, focus efforts and saves time.

• It focuses on the gap. The gap between what is and what should be reflects a change or deviation from the norm, requirement, standard or expectation.
• It states the effect i.e. what is wrong, not why it is wrong.
• A well defined problem should be measurable. It avoids broad and ambiguous categories like communication, productivity but rather focus on how often, how much, when.
• It highlights the significance of the effects.
• It avoids "lack of" or "no" statement, these implies solutions. E.g. "lack of food" or "no" food implies food as the solution, while the "problem" is hunger.

To prevent the loss of data, the data collection phase of root cause analysis should begin immediately following the occurrence identification. Information to be collected includes conditions before, during and after the occurrence, environmental factors, personnel involvement and any relevant information to the occurrence. In the case of accidents, the area should be secured, photographs taken from different views while physical evidence such as damaged components, blown fuses, naked wires, spills, job schedule and procedures, equipment maintenance report should be preserved. All data obtained should be further scrutinised to ascertain accuracy as irrelevant or false data can be disposed. Methods for gathering of information include;

Interviews: The first criterion is to ensure that all relevant persons who are able to give first hand information as eye witnesses to the occurrence have been identified. Before embarking on an interview, the interviewer should prepare questions to ensure that vital information required is obtained from the interviewee thus it is a fact finding process. Those to be interviewed should ideally be participants and witnesses, people who are knowledgeable about the occurrence, personnel familiar with the problem, personnel who have previously undertaken roles relevant to the occurrence. The interviewer could

consider a "walk through" and collection of written statements as part of the interview process. For optimum results an interview should be conducted in a relaxed and quiet atmosphere, possibly over a cup of beverage and witnesses should be interviewed separately.

Statements: Written statements can also be collected from witnesses. A complete statement will generally contain the following;

A. Full name and address (current and permanent) of the witness
B. Name and address of witness organisation
C. Profession, experience and any necessary details about the witness

The investigator will not be the only person taking statements as the following four other categories of person are authorised to do same in the United Kingdom (UK)

- An Inspector from the enforcing authority i.e. the HSE or the local authority in the UK.
- The police
- A person authorised by the Crown Prosecution Service in the UK
- An Inspector from the Environment Agency in the UK with respect to incidents involving pollution/emissions.

Review of records: The review of relevant documents like repair/maintenance records, inspection, procedures and instructions records, operation logs, correspondence (including shift handovers), vendor manuals, safety analysis report/ technical specifications, equipment history records are essentials in the data collection phase as they reveal a lot of information. Other documents include safety performance management system/occurrence reporting and processing system (SPMS/OPRS), work orders, trend charts and graphs, operational safety requirements, equipment manufacturer and supplier records.

Other information: Besides the above sources of information, the investigator should view the physical layout of the system, component and working area, evaluate the need for destructive/non-destructive failure analysis, operating experience etc. The assessment phase of the investigation process involves the analyses of all data collected with the aim of identifying causal factors of the incidence. Findings are summarised and categorised by cause category which generally fall into personnel error,

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design problem, equipment/material failure, management problem, inefficiency in training, inappropriate procedure. These categories cut across elements necessary to perform task and also the effectiveness of equipment and personnel through a proper design layout and structured training program. It is important to note that these elements must be adequately managed by the management. The causal factors relating to an occurrence can be associated with an external factor in a logical causal factor chain as shown in Figure 1.

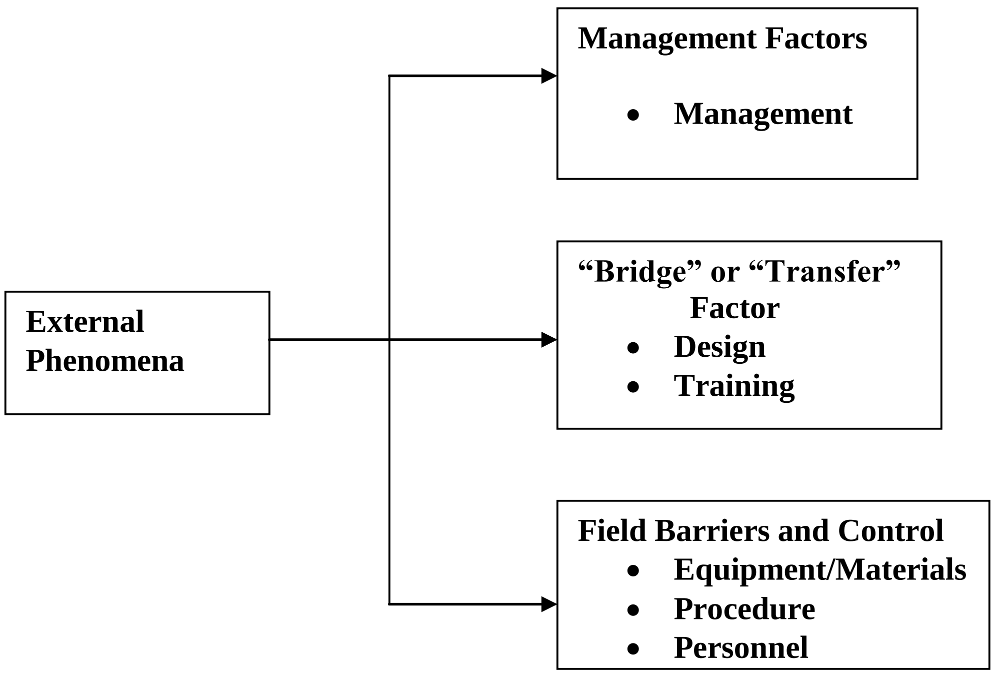

Figure 1 Causal factor categories associated in a logical chain

In order to perform an effective assessment, report causal factors and develop corrective measures, the following steps should be taken.

I. This involves the identification of the problem which reveals the unplanned action or conditions which led to the occurrence rather than the resultant effect. For example a boy opens a fire exist unknowingly, raising a false or fire alarm. In such a scenario, the occurrence is the actuation of an engineered safety feature which was planned or intended whereas what led to the occurrence was the boy in a rush opened a fire exist without taking notice.

II. Determination of the significance of the occurrence: Knowing the severity and likelihood of a reoccurrence of the event will guide the investigator in subsequent steps to be taken in the RCA.

III. Identify the conditions and action immediately preceding and surrounding the incident.

IV. Good assessment of the causal factors identifies the root cause of an incidence and aids investigators in developing corrective actions which will prevent a reoccurrence of the undesired event.

The reason for the existence of the causes in the preceding identification steps should be identified. Findings should be summarised and cause classified according to the cause category in Appendix A. In selecting causes, direct cause factors and system inadequacy are to be considered rather than causal factors. Root cause must be specific to the occurrence and an explanation of the direct cause.

Determination of the root cause will lead to the development of corrective action which will prevent reoccurrence of the incident.

3. Occurrence reporting

Occurrence report must be entered into the occurrence reporting and processing system (ORPS), guided by the OPRS user"s manual. Direct, root and contributing causes are matched with cause categories as specified in Appendix A.

1. Accident investigation must be realistic and represent a description of the occurred event.
2. Investigations should be non-causal and aimed at describing the occurrence rather that blaming persons.
3. Consistency in investigation will boost performance.
4. The investigation process should be orderly, systematic and focused on determining the cause of the incident.
5. A functional investigation will help the investigator identify related events and discard irrelevant information.
6. A criterion must be set for the identification and definition of data required for describing the incident.
7. A good accident investigation should be comprehensive and void of ambiguity.
8. The results of the investigation process should provide appropriate corrective actions or control required to prevent reoccurrence.
9. Investigation reports must be easily understandable.
10. The result of the investigation should be satisfying to the investigators and the management.

Figures produced by UK Government sources show that 1.6million incidents result in injuries a year and 750,000 workers have suffered from ill health caused or made worse by their work. This results in the loss of over 30million working days and a cost to industry of about £700million. The overall cost of incidents at work and work related ill health to workers is estimated to be between £4000 and £9000 million a year excluding societal cost associated with after care of the workers involved in these accidents. The cost of accident/incident(s) in the oil and gas industry can be directly linked to the effective management of safety, health and environmental issues within an organisation. An organisation loses money when people are injured, plants/ machinery damaged, loss of life, product wasted etc. The severity of the outcome of an incident depends on the inability of the organisation to correctly identify hazards and control associated risks.

Organisation"s which apply the principles of effective management to safety, health and environmental issues are generally known to perform well irrespective of their size. The loss control theory expresses the relationship between the number of incidents involving fatal injuries, non-fatal injuries and property / facility damage and near losses or learning opportunity forming the peak, middle and base of the triangle. It is imperative to identify and analyse near loss as it provides the opportunity to learn similar or same incident occurrences. Unfortunately, near loss are usually not reported and thus considered insignificant to absent. Workers will usually believe that since the last incidence was mere part damage, it cannot be any worse. However, this might not always be the case and thus near loss should be investigated to prevent reoccurrence. Fig.2 depicts an example of an accident triangle.

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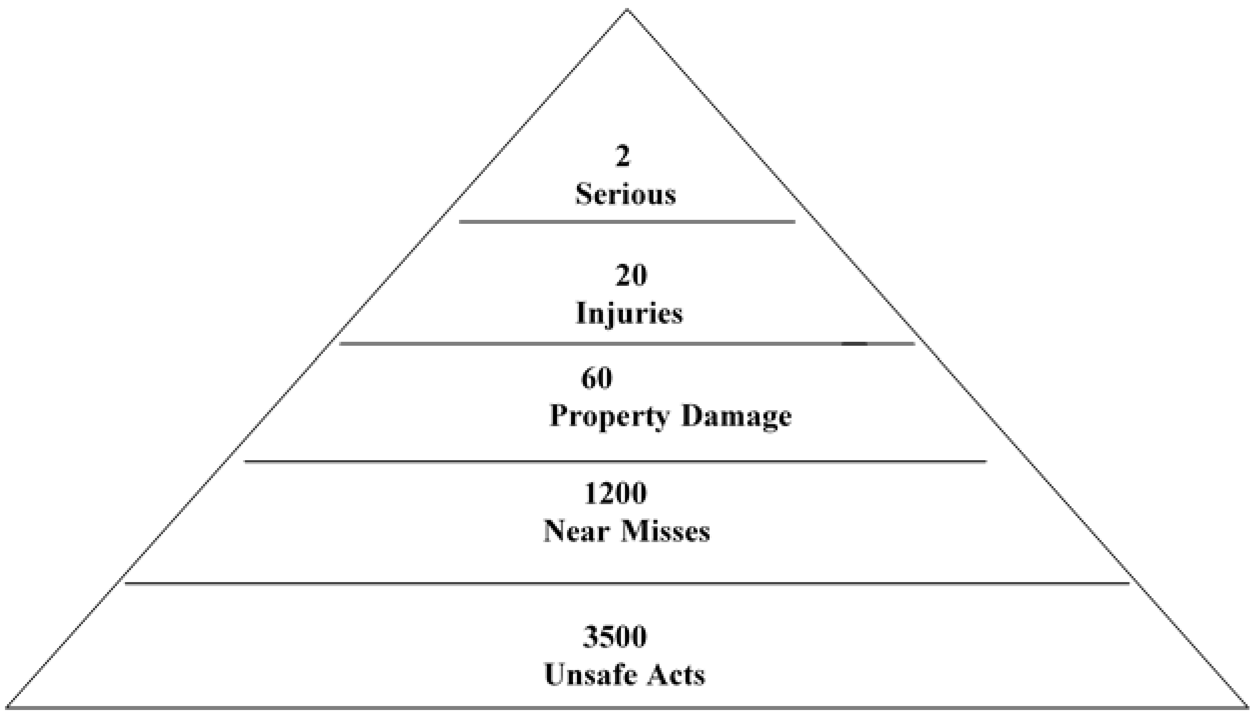

A comparison can also be made between the ratios of insured costs to uninsured cost. It is important that an organisation analyses its insured costs so as to ascertain what types of insurance cover they have in order to estimate their potential loss. Below is a relationship between insured/uninsured and direct/indirect costs.

INSURED

Employer"s Liability Public Liability Damage to Building Damage to Vehicle	Business Interruption Product Liability
DIRECT	**INDIRECT**
Sick Pay Repairs Product Loss	Investigation Cost Loss of Goodwill Loss of reputation Replacement Staff

UNINSURED

The following scenario shows a typical example of an occurrence and the cost involved in this case;

- British Petroleum (BP) Refinery Explosion in Texas, U.S.A

The explosion and fire occurred after workers responsible for the startup overfilled the raffinate splitter tower and overheated its contents which resulted in over pressuring of its relief valves. Liquid was pumped into the tower for about three hours without any liquid being removed or action taken to achieve the required low liquid level as stated in the startup procedure. The liquid level in the tower just before the loss of containment was found to be 20 times higher than normal. This occurrence would have been prevented if the automatic liquid level control was activated as mandated in the startup procedure. The workers at this point decided to start removing liquid from the tower and this exacerbated the incident. Rapid heat exchange between the overheated liquid being removed from the bottom of the tower and the liquid feed continuing to flow into the tower, significant vaporisation occurred, over pressuring the relief valves and ultimately overwhelming the adjacent blow down unit. The investigation teams revealed that about 1,100barrels of liquid was discharged to the blow down unit which had a design specification of 390barrels.It is also estimated that 50barrel over flowed the tower leading

to the formation of a hydrocarbon vapour cloud at ground level. The investigation team observed that the sewers were not the primary route for the formation of the hydrocarbon vapour that subsequently exploded. The damage to the sewer system was as a result of secondary fires caused by the main explosions which source of ignition was unknown. Unit supervisors were said to be absent during critical parts of the startup and unit operators did not take effective action to control the process upset or to sound evacuation alarms after the pressure relief valves opened.

- Failure to adhere to laid down procedure led to greatly overfilling the raffinate splitter tower
- Venting of liquids caused by overfilling and overheating of the liquid in the tower lead to liquid relief to atmosphere and the subsequent explosion
- The location of many people too close to a blow down unit, congregated in and around temporary trailers which were inappropriately sited
- The continued use of a blow down unit for light-end hydrocarbon use when inherently safer options were available and could have been installed
- 15 workers lost their lives
- Many more injured
- Though the actual cost of the accident cannot be ascertained, the company estimates to invest about $1 billion dollars to improve and maintain the site due to the accident occurrence
- Down time
- Cooperate image
- Insured and uninsured cost

CONCLUSION

The final investigation report clearly established that the underlying causes named above and management system failures contributed to BP"s tragedy. Accident investigations are aimed at establishing all the facts that relate to an incident and drawing conclusions from these facts. Analyses of these facts identify the immediate and underlying causes on an event. Accident investigation reveals the unseen weaknesses in management control and this helps to improve and develop a good safety culture within the organisation. Through accident investigation, the investigator(s) is able to recommend corrective action to be adopted to prevent a reoccurrence of the incident by trailing the chain of events which occurred.

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