Systematic Human Error Reduction and Prediction Approach while Drilling

[1]Md Imtiaz, [2]Anamitra Munsi, Dewarshi Nayan, S.Dei
Indian School of Mines, Dhanbad, India

Abstract— Various Human factors tools have been tried and tested till date. This project involves the study on the wide-ranging aspects of interaction of human beings within theirworking environment, their overall performance and thus illustrates and judges the probability of occurrence of human errors during such interaction. The results obtained havebeen derived from realistic practical working data, since these techniques have already been applied to tasks and personnel in the Oil and Gas Extraction business. Some ofthe Human factor Tools exploited in the arena includes:

1. Sequential Timed Event Plotting Procedure (STEPP) (which has been developed especially for this project),

2. Hierarchical Task Analysis (HTA),

3. Systematic Human Error Reduction and Prediction Approach (SHERPA),

4. Safety Culture Questionnaire (SCQ)

5. Individual Interviews and Focus Group meetings with drilling personnel, both on and off the rigs.

STEPP is a multiple-event-sequence technique, which by accumulating the scenarios surrounding the accident, builds incident investigation and accident procedures. Learning lessons from the experience in the past, this method aims to identify the casual paths and multi-causality of the incident under investigation. It clearly differentiates between humans, vegetation, actions and events. Instead of focussing on the superficial events, the underlying root causes are sought. Interviews with team members, live and recorded transcripts, hand-outs from alarm lists, data from measured variables and various other data related to incident are collected to develop the model.

Next, the personnel and vegetation are plotted down the vertical axis with the timeline on horizontal axis. The length of the finished graph may extend to several feet. Then, lines depicting casual paths can be drawn between events. The paths may lead to several events or not even a single one. Lastly, the underlying root causes are sought after completion of the analysis.

Index Terms— STEPP, SHERPA, HTA, SCQ, HSSE, Error-reduction, Prediction, Analysis

1 INTRODUCTION

For the past few years, the importance of Human Factors in the management of safety-critical industries has been critically identified. The domains of Nuclear and Aviation energy have significantly contributed to the development of techniques, owing to the newly formed concepts. However, it cannot just be assumed that techniques and analysis of Human Factors developed for Nuclear and Aviation fields can be directly applied to the Oil and Gas Industry. In order to classify basic causes of human error and poor safety climate, directly in relation to the drilling environment, it is essential to design a systematic process for Human factors tools. As identified by Human Factors, the root cause of major accidents is human failure. Although most have multiple causes, over 80% Will be having a cause which is related to human performance.It is evident that Human Factors are contributing to the incidence of kicks and to their effective handling. Hence, it is suggested that the intervention of Human Factors techniques will noticeably reduce the incidence of induced kicks, near misses, lost time incidents and other accidents. With the ongoing advancement in technological experience and competence, accidents and lost time incidents have supposedly reached a low magnitude, but most concerned companies have discovered that they have reached a plateau.Assessment of Human Factors in all activities, focusing on the behavior of individuals in the work system must be carried out, if a step change in performance is needed. Risks associated with human performance must be identified.Being concerned with adapting technology and the environment to the capacities and limitations of humans, the major challenge for Human Factors is to act in a prescriptive way to make systems and working practices safer, more secure and more efficient.

Root cause analysis is a tool designed to assist incident investigators todescribe what happened during a particular incident, to determine how it happened and to understand why it happened. The definition of a root cause varies among authors, with different ‘levels’ of causation being adopted by different systems.

This project carried out involves the study on the wide-ranging aspects of interaction of human beings within their working environment, their overall performance and thus illustrates and judges the probability of occurrence of human errors during that interaction. The results obtained

- [1]*Md Imtiaz is currently pursuing Bachelor degree program in Petroleum engineering in Indian School of Mines-Dhanbad, India, PH-+918804926051. E-mail: mdimtiaz1098@spemail.org*
- [2]*Anamitra Munsi is currently pursuing Bachelor degree program in Petroleum engineering in Indian school of Mines-Dhanbad, India, E-mail: anamitramunsi2@mail.com*

have been derived from realistic practical working data, since these techniques have already been applied to tasks and personnel in the Oil and Gas Extraction business.

The Human factor Tools exploited in the arena include:

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5. Individual Interviews and Focus Group meetings with drilling personnel, both on and off the rigs.

2. SEQUENTIAL TIMED EVENT PLOTTING PROCEDURE (STEPP)

Sequential Timed Event Plotting Procedure or STEPP is a technique used to identify the type of accidents which has already happened and their potential causes. In this technique a sequential event plotting is carried out which identifies the type of events that commenced which led to the accident, then each thing associated with the event is uniquely identified and investigated. In this procedure, humans and things are distinguished from the actions and events. After understanding the basic incidents that occurred, this method analyses the primary causes of the incidents and then from there, the root causes are identified.

Following the above procedure, data is collected which shows the basic HOC (Hazard Observation Card) classification and the root causes which are responsible for the incidents.

Top 10 HOC Classifications Compared to Top 10 Root Causes of Incidents		
Rank	HOC Classifications (old)	Root Causes
1	Tools - In Unsafe Condition	Other
2	People - Unsafe Act	Individual Performance: Procedures
3	Procedures - Not Followed	Individual Performance: Training
4	People - PPE Not Used	Management System: Management System
5	Engineering - Maintenance	Individual Performance: Human Engineering
6	People - Unsafe Position	Individual Performance: Work Direction
7	Procedures - Inadequate	Management System: Procedures
8	Engineering - Electrical	Design: Design Specs
9	Environment - Chemical	Equipment/Parts Defective
10	Tools - Wrong for the Job	Preventive/Predictive Maintenance

This table demonstrates the major hazard causing actions and the root causes responsible for the actions and it also explains how those root causes can be tackled and elevated simultaneously.

A detailed analysis was also done to understand the major Hazard Observation Cards that were responsible for the accidents happened in the year 2009 in the area.

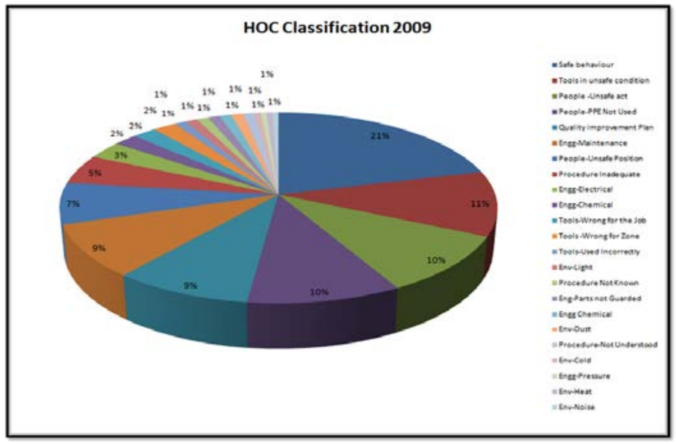


Fig 1.1: Pie-chart depicting Hazard Observation Cards Classification

It can be clearly observed from the figure: 1.1, that major Hazard Observation Card is the unsafe behavior, which is the major cause for the accidents in most cases. Even after safe behavior, nearly 11% of the accidents took place due to the reason that the tools were placed in unsafe conditions. Unsafe actions by the people and the use of incorrect procedures followed by them were also major contributors to the accidents that happened in 2009 and had a share of about 10% in the total hazards that happened. Improper maintenance and quality improvement plan have led to accidents sharing about 9% of the accidents happening in that area. Use of incorrect tool for the job and incorrect tool for a particular zone, not proper light, environmental dust, cold environment, heat and noise contribute about 1-5% to the total accidents happened but the workers need to be careful about them.

All these hazards have happened due to some root causes responsible for each accident and in the survey the following major causes were identified.

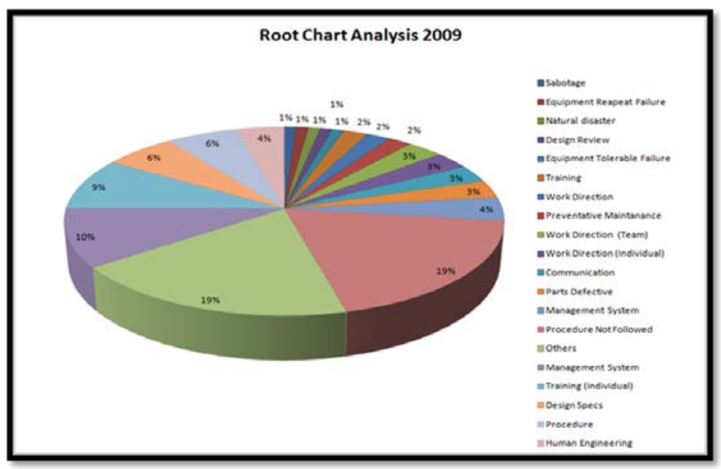
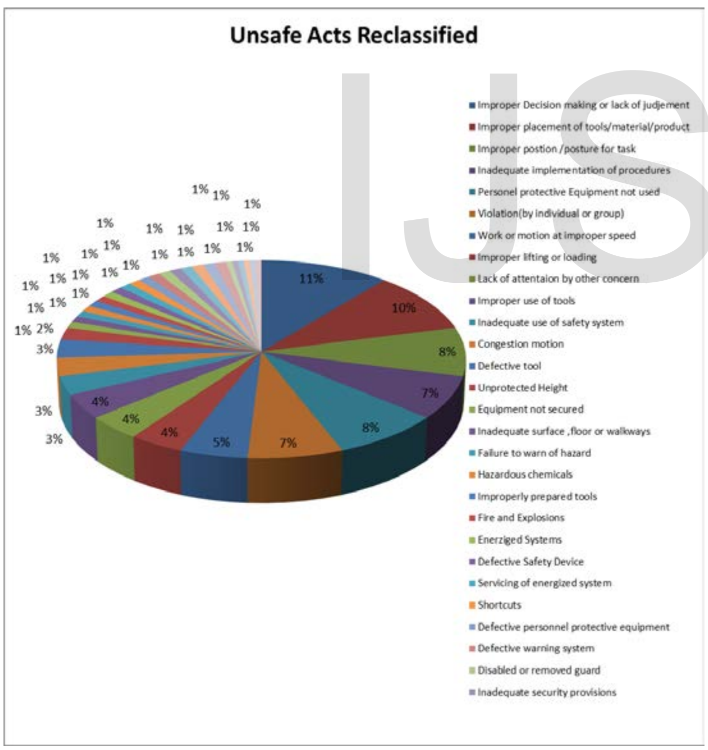


Fig 1.2: Pie-chart depicting Root Chart Analysis

The major root causebehind these discrepancies which had led to the accidents is due to the reason of not following the correct procedure by the workers at the site. The failure of the management system at the site and insufficient training of the individuals are also responsible for the hazards. The failure in keeping proper management causes malfunction in the site and each quipment is not assembled at the proper place, causing confusion and leading to accidents. If the individuals are not properly trained then they remain unaware of the correct usage, order of usage of the tool and the safety precautions associated with the tool- causing accidents at the site. Improper design causes the uneven load distribution and may also cause the collapse of structures leading to catastrophe. Following incorrect procedure or incorrect order in the field may also cause about 6% of the accidents in the area.

Improper communication between the members and the lack of coordination were also the factors that increased the chances of disasters in that area. Defective parts and tool wear and tear were also responsible for the accidents in the area. Equipment repeat failure, natural disaster, sabotage, equipment tolerable failure, design review etc. contribute about 1% each to the accidents that occurred in the area. These are not the major contributors but the risk associated with them needs to be mitigated to avoid any accident.

As already discussed there are various hazard observation cards which are the primary causes for accidents. 11% of the accidents that commenced in the area occurred due to unsafe acts by the people. There are a number of limitations of the previous system of categorization, whereby, due to wide scope of the definition of "People Unsafe Act", a number of issues could be legitimately assigned to this category which were significantly different in nature. The different topics all happened due to the unsafe acts by the people are widely different in nature and needs to be classified separately as follows:-



The above chart shows various unsafe acts which has led to the accidents in the area. Improper decision making is the major factor contributing to about 11% of the accidents happening due to unsafe acts by the people. Lack of proper decision making at crucial times may cause malfunctions in the system and can cause big accidents. Improper placement of tools can hinder with the natural procedure of the work and may cause malfunctioning of the equipment. About 10% of the accidents happened in the same process. Following incomplete procedure and improper posture of the workers may cause mishandling and pandemonium, causing accidents in the world. If proper protective equipment is not used then it might lead to personal hazards to workers. Consequently, about 8% of the accidents happened due to this factor. Defective tools, unprotected height, chemical spills, fire explosives, energized systems, faulty safety devices etc. have contributed to about 1% of the accidents but they need to be speculated in order to avoid any possible accident.

HIERARCHICAL TASK ANALYSIS (HTA)

Hierarchical Task Analysis refers to the analysis of accomplishing a task that includes detailed description of each of manual and mental activities involved in drilling, task and element durations, task frequency, task allocation, task complexity, environmental conditions, necessary equipment and any other unique factor required for one or more people to perform a given task. Adequate amount of research in the field of applied behavior analysis has in the process given rise to task analysis. The utility of task analysis is distinctly related to the user. The information derived can be utilized for personnel selection and training, tool or equipment design, procedure design (i.e. design of checklists or decision support systems), automation and various other purposes, thus proving successful in removing the ambiguity surrounding people's everyday activities.

Owing to the wide range of problems in safety management, the multiple applications of this technique include time-and-motion studies during drilling activities, personnel selection for drilling or training, along with providing a broader and deeper understanding of task performance. Apart from the core principles to guide the whole process, it is possible to undertake the fundamental approach in order to support the necessities of any domain which is under consideration.

The task analysis will essentially highlight the actions which could be performed in a more secure way, in order to improve safety and effectiveness overall. Hierarchical Task Analysis might be used to study closely the activities of a worker before a risk assessment is undertaken and hence, could exclusively form an effective basis for preparing Safety Case material.

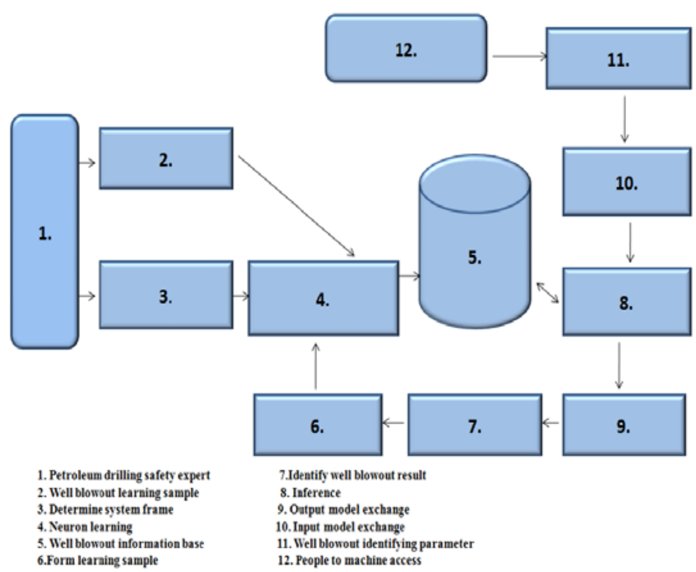


Fig 1.3: Schematic Flow Diagram representing Hierarchical Task Analysis

As depicted by the schematic flow diagram above in figure: 1.3, Neuron learning is carried after the petroleum drilling safety experts provide either a well blowout learning ample or determine the system frame. While on one hand, this leads to the well blowout information base, on the other hand, the people entitled to access the machine identify the well blowout parameter and through the input model exchange, gradual flow of information is executed to determine the inference from the information base and vice versa. After the vital exchange of information, the inference assists in obtaining the well blowout result via the output model exchange. Consequently, a learning sample is formed, which is henceforth forwarded to the well blowout information base and the cycle continues in a similar fashion.

Adequate protection from fire requires early alarm and prompt notification of existence and location of the hazardous condition. To accomplish this, a combination of automatic gas, smoke and heat detection equipment is installed throughout the platform, and on detecting the hazard, effective extinguishing agents are automatically and immediately applied to the hazard source. Automatic foam and water spray systems are installed in selected areas, and Halon 1301 suppressant gas is discharged automatically at discharged location. As a back-up to the automatic systems, manual combination of dry chemical and aqueous film forming foam/water spray twin agent hose reels, water/foam aqueous film forming foam monitors and a variety of portable fire extinguishers are located throughout the platform.

The platform should preferably be equipped with separate fire water and aqueous film forming foam (AFFF) ring mains. The fire water ring main is fed from a minimum of atleast two separate pumps. This will supply fixed water spray systems, pre-action sprinklers and wet pipe sprinkler systems, hose line stations, water curtains, deluge installations and remote-controlled monitors. Modular dry powder extinguishing devices can be installed at several locations to supply manual, twin agent (dry chemical-AFFF/water) stations. Halon 1301, total flooding extinguishing systems, is installed at critical electrical equipment locations. First-aid hand operated fire extinguishers are locating throughout the platform. A combination of coincident smoke and heat responsive fire detectors, combustible gas detectors and manual alarm stations are interlocked with platform's alarm, ventilation and process control system (PCS). Structural steel members and partitions are encased in fire protective materials to ensure specified degrees of fire resistance.

The complete process of workflow for fire protection is demonstrated thoroughly as follows in figure: 1.4:-

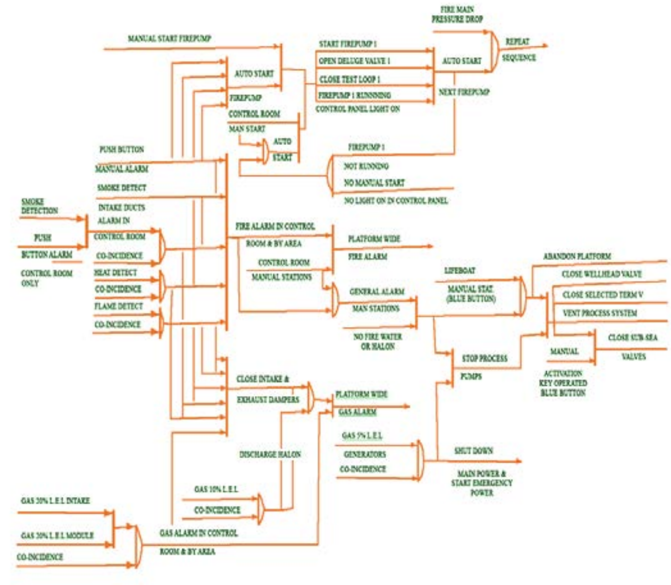


Fig 1.4: Figure depicting complete process workflow for fire protection

SYSTEMATIC HUMAN ERROR REDUCTION AND PREDICTION APPROACH (SHERPA)

Systematic Human Error Reduction and Prediction Approach is advancement in the hierarchical task analysis. In this process of collecting information and interviewing the operator who is working on the task to be analyzed. Each collected information is separated according to the preset parameters and then each task is separately analyzed to understand the human error which would have caused the event to occur. After that it is analyzed whether the event is potentially hazardous or critical. It not only identifies the problem but also comes out with solutions and precautions that would reduce the probability of that accident to happen in the future.

In SHERPA this goal is achieved by exhaustive investigation about each step that lead to happening of a particular event. Then at each step the correct procedure and the human errors that could happen are all identified. The consequence related with each event is then further predicted and its effect on future events is also studied. All possible combined impact of the errors are studied and evaluated whether they are critical or not. The consequences are categorized as high (most frequent), medium (occasionally happening), low (not occurred but possible). Remedies of each error are found and suggested so that errors could be reduced to maximum extent.

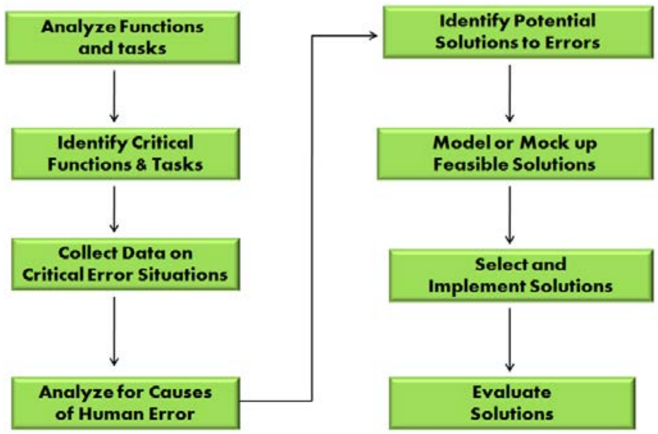


Fig1.5: Systematic Workflow process for SHERPA

The above flow diagram (figure: 1.5) shows the steps which are taken in SHERPA analysis. First step is to analyze the functions and the tasks that lead to happening of a particular event. This can obtain by initial data collection and interview of the operator. From all the tasks those tasks are separated which are critical and have the most impact on the event. An error in these event can be very hazardous so special care needs to be taken to identify the possible errors in those areas. The data is collected about the critical error situations and the causes of the human error are also analyzed to understand the type of errors occurring in each situation. The solutions to errors are identified and proper feasible solutions are selected and implemented. After the implementation of solution the solutions are again evaluated to confirm the feasibility of the solution. The basic objective of this process entirely is to identify errors which have occurred and would possibly occur in future. It also aims at developing a system that would be more error tolerant and would function smoothly in case an error occurred and till the error in found out and rectified.

Condition \ Action	Deluge System	Sprinklers Wet Pipe	Cdse Inteke Damper	Close Extract Damper	Halon 1301 Release	Ventilation Shutdown	External Shutdown-Gas	External Shutdown-Fire	Alarm At Local Panel	Alarm at Main Control Panel
Gas 20% in Intake Duct			X	X					X	X
Gas 20% in Module									X	X
Gas 60% in Module			X	X	X		X			
Flame Detector-Single U/V									X	X
Flame Detector-Coincidence			X	X	X			X		
Smoke Detector-Single									X	X
Smoke Detector-Coincidence			X	X	X			X		
Heat Detector-Single Electric									X	X
Heat Detector-Coincidence			X	X	X			X		
Local Manual Release-Electric			X	X	X		X	X		
Local Manual Release-Pneumatic	X		X	X			X	X		
Manual Call Point									X	X
Ventilation Supply Failed									X	X
Ventilation Extract Failed									X	X
Smoke Detector in Intake Duct			X	X					X	X
Heat Detector Coincidence	X		X	X				X		

Fig 1.6: Figure representing analysis of actions to be undertaken corresponding to a particular situation

The following example (figure: 1.6) shows the analysis of how a particular condition is dealt with and what action needs to be taken to tackle that particular problem. Like for example of the case when there is 20% gas present in the intake duct then actions that need to be taken are to close the intake damper and to close the extract damper. To alert about the problem alarms should be installed at the local panel and the main control panel so that the officials present near either one of them would know about the situation and take necessary steps to avoid any further damage. If flames are detected in the system then intake and extract dumpers are closed and external fire shutdown is done as the precautionary measure. Data also indicate that on detection of smoke and heat similar steps need to be taken. In all these conditions alarms need to be set up to ensure proper alert systems. This is how this analysis is done.

CONCLUSION

A number of root causes 'procedures', or 'systems' have adopted a battery of techniques that can be applied at particular stages of the investigation. It is apparent that there are three key components that need to be applied to ensure effective root causes analysis incident investigation, which are:

□A method of describing and schematically representing the incident sequence and its contributing conditions.

□A method of identifying the critical events and conditions in the incident sequence.

□Based on the identification of the critical events or active failures, a method for systematically investigating the management and organizational factors that allowed the active failures to occur, i.e. a method for root causes analysis.

The study has identified specific areas for improvement as well as pinpointed the underlying deficiencies. Thus the proposed initiative can tackle the root causes effectively. This will eliminate generalized initiative and a trial and error approach to solving the concern. Recommendations have been made for continued improvement in the Oil and Gas Industry. It is believed that the project has proved that Human Factors can offer powerful tools for the identification of root causes and remedial strategies in the Oil and Gas Industry. In summary, these analyses show that Human Factors has a valuable contribution to make in achieving step changes in safety and efficiency of drilling operations.

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