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Safety Interventions inVisakhapatnam HPCL

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Abstract

The failure of the safety practices have led to the need to redefine the safety activities which should beincorporated into a particularsafety and health program. This has also led to the need to determine the level of resources to be allocated to the implementation of the safety and health program. Mostbehavioral based studies have considered intervention as a single factor which failed to observe the interactive effects of other safety activities. The evaluation and implementation of a single intervention factor could be justifiable in situations where the other interactive factors are assumed constant. In 1995, in the study conducted by the Human Factors in Reliability Group of the United Kingdom Health and Safety Executive, the role of unsafe human behaviors was considered as the major contributory factor inindustrial or workplace accidents. Four types of unsafe behaviors were highlighted and management oriented intervention was recommended as the applicable solution. Their study provided a safety audit survey technique which incorporated a questionnaire and interview system to identify areas of the safetyprogram which needed to be improved . The use of qualitative technique in the analysis of safety behaviors of the employees did not produce any meaningful results to the study

Keywords: Safety interventions, Regression equation, Response Surface plot.

1. Introduction

India has proven to be a natural gas giant in the region and to the energy producing community of the world. The India sub-surface is according to the present knowledgemainly gas prone, with some potential for future oil discoveries. Within the 3,287,263 sq km of its political territory, As on 15 August 2023, there were 23 crude oil refineries in India, of which 18 were state-owned, 3 were privately owned and 2 were joint ventures. The total oil refining capacity in India stood at 248 MMT,rising from 241.7 MT in the year.

The energy management of the country is thus become most vital for efficient use ofits 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 forthe 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, India is comparatively in suitable position in terms of naturalgas discovery and production that is powerful enough to lead a nation to gain economic boost. From the middle-east energy scenario, India is determined to take important lessonsto 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 work will show the ways to develop long term plans for effective management of the present and incoming gas fields of India and will emphasize on the techniquesto follow for proper development with time.

Outline of Methodology:

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

Data collection of Safety intervention & incident record from the health, environment and safety department of a multinational oil and gas company in India.

Analyze the impact of safety resource or budget increasing on incident rate reductionand representation by a graphical presentation.

Selection of those of the best safety interventions by Pareto Analysis.

Development of a safety model in order to determine the safety intervention factors which would be essential to yield the desired incident rate reduction.

Obtaining the safety model using Multiple Regression Analysis & using Analysis of Variance forthe testing of significance of the model.

Using of response surface methodology in the determination of the effectiveness of safety resource allocation.

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.

Evaluation of Safety Intervention Model:

HPCL visakha Refinery is one of the world's leading integrated energy companies producing safe, reliable energy now and for the future. Through its subsidiaries around globe, HPCL visakha Refinery produces natural gas and condensate from three fieldsin the northeast of the country.

Table 1: Safety interventions those are practiced at HPCL visakha Refinery

S.NO	Safety interventions	S.NO	Safety interventions
1	Auditing	13	Procedure & Safe & WorkPractices
2	Communication	14	Risk Management
3	Contractor safety	15	Supervision
4	Design	16	Training & Competency
5	Emergency response	17	Leadership & Accountability
6	Human factor	18	Qualification Selection & Pre-job
7	Incident Investigation	19	Employee Engagement & Planning

8	Inspection/Quality control	20	Work in Progress
9	Management of change	21	Evaluation, Measurement & Verification
10	Natural phenomena	22	Safety awareness & Motivation activities
11	Pre-Startup-Safety Review	23	New tools & equipment designmethods and activities
12	Preventive maintenance/Rep eatFailure		

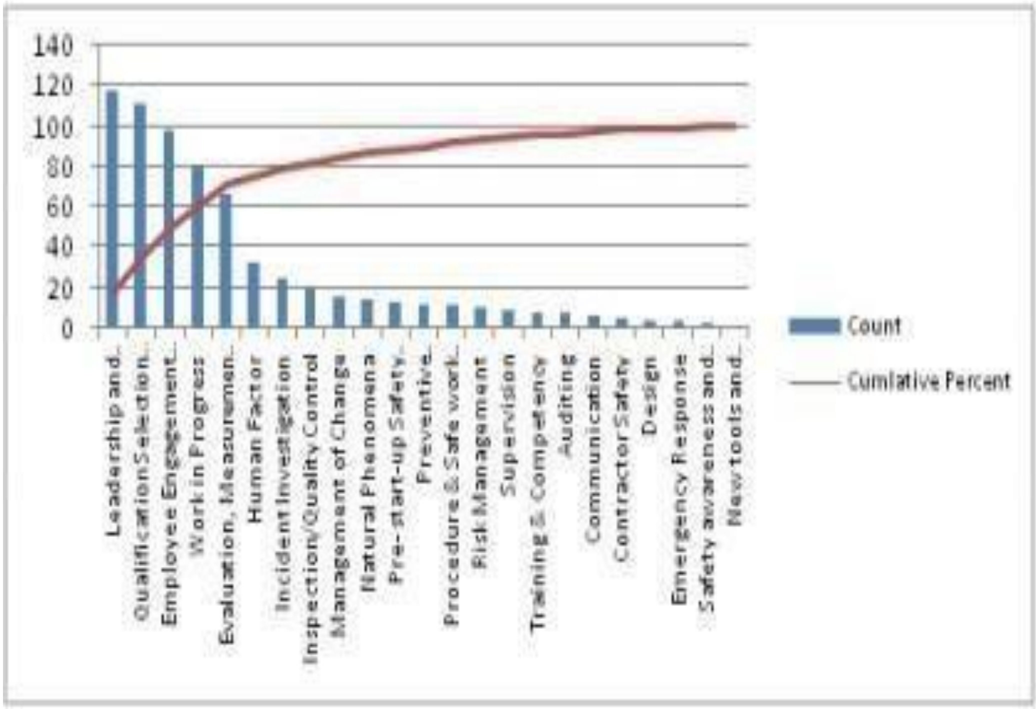


Fig. 2: Pareto chart for relative quantitative status of safety intervention items in HPCLvisakha Refinery

MODELING OF SAFETY INTERVENTIONS:

Table2: Scope of implementation is designed as per safety interventionimplementation process

Intervention	Scope of implementation
Leadership and Accountability	1. Process sponsor engagement in employee Health Environment and Safety (HES) management Process advisor engagement in employee HES management 3. Organizational targets are established for performance indicators 4. The company leadership periodically reviews employee HES performance, recommends and implements improvement 5.The company leaders and managers establish, provide resources and participate in employee HES management

fications Selection and Pre-Job	Approved employee lists are maintained 2. The employee qualification and selection process address HES performance considerations 3. Pre-Job meetings with employees are conducted prior to startof work A motivational/safety incentive for the employees is in place HES training development and verification
loyee 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 employeerepresentatives are conducted. Joint employee-contractor meetings are held
	4. Regular field visits are conducted by company managers andsupervisors for the purpose An employee safety plan that addresses all risk assessment is in place
Work in Progress	Incident investigation and review (II&R) process Job safety analysis & hazard assessments are conducted 3. On- site HES monitoring is provided for high risk and/or large jobs 4. Management reviews conducted joint on employees and contractors Safety permits are issued and used
uation, Measurement and Verification	Joint post-job evaluations are conducted part of evaluation Results communicated to contractors 3. Lessons learned are evaluated and incorporated into future contracting efforts

Multiple regression safety models:

Above-mentioned five safety interventions are mentioned as five factors (A, B, C, Dand E) that are mainly responsible for safety. The percentage of each of these five factors to the total available man-hours corresponds to x1, x2, x3, x4 andx5 where x1, x2, x3, x4 and x5 are regarded as the independent variables for the multiple regressionsafety model. The dependent variable is the total incident rate recorded per 200,000 hour which is denoted by function y as seen in Eq. 1. Based on this, a mathematical representation is expressed for the interactive relationship between the independent and dependent variables as shown in Eq. 1.

$y = f(x1, x2, x3, x4, x5,)$

Table 3: Designation of the prominent safety interventions

Safety intervention activity	**Fact**	**Input variables**
Safety induction training	A	x1
Work permit system	B	x2
Incident investigation	C	x3
Contractor safety	D	x4
Leadership and accountability	E	x5

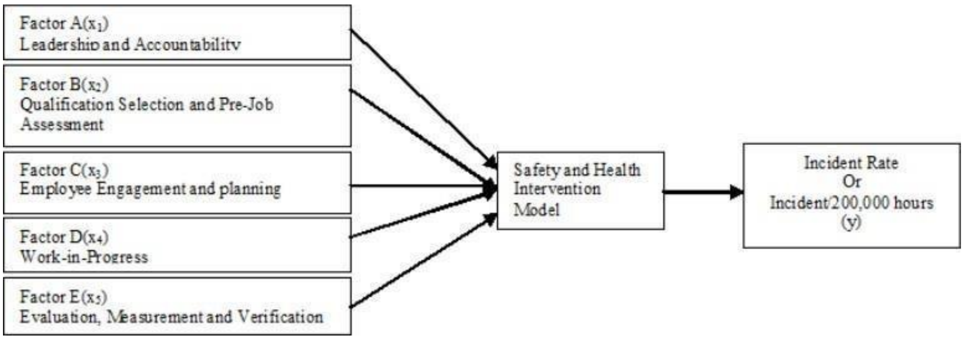


Fig:3 Representation of the safety intervention model

Safety Intervention Data:

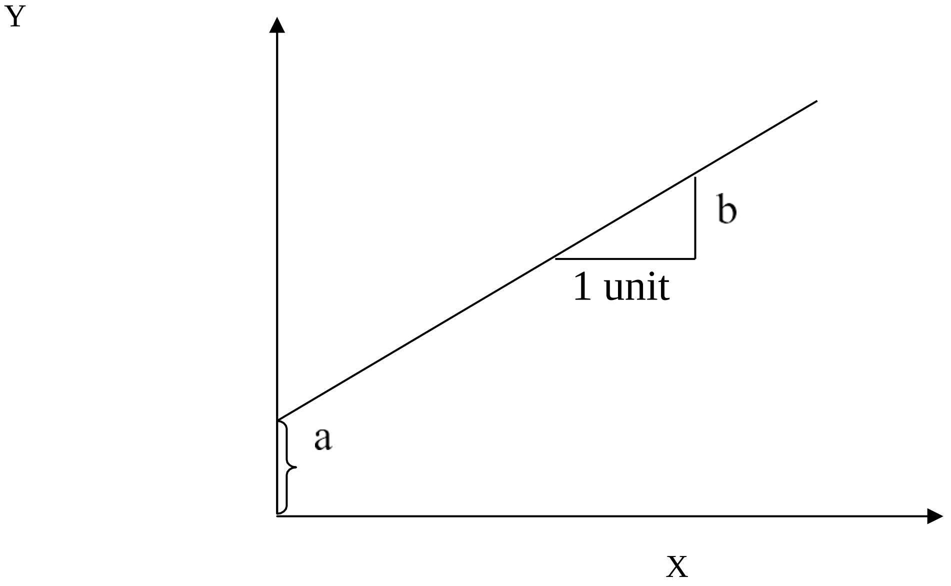
Table 4: Man-hours for different safety interventions applied in Project 6

Year2022	**Applied safety interventions**					
	Actual man-hours (in thousand hours)					
	Project 6 (P6)					
	A	**B**	**C**	**D**	**E**	**TOTAL**
Jan	3	1	1	19	2	26
Feb	3	1	1	26	2	33
Mar	4	1	1	31	3	40
Apr	6	1	1	27	3	38
May	5	1	1	23	3	33
Jun	5	1	1	17	3	27
Jul	7	1	1	24	3	36
Aug	5	1	1	22	2	30
Sep	5	1	1	14	2	23
Oct	31	1	1	35	2	70
Nov	7	1	1	10	3	22
Dec	5	1	0.5	11	3	20.5

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 analysisto find patterns in unstructuredand semi-structured customer data that can be used to create a more positive customer experience and increase sales.

Simple Linear Regression Model:
In regression analysis, as in other types of statistical studies, we usually proceed by observingthe sample dataand using the results obtained as the estimates of the corresponding population relationship.



Regression Equation of Y on X:
The regression equation of Y on X is expressed as follows:
$Y_e = a + bX$

Regression Equation of X on Y:
The regression equation of X on Y is expressed as follows:
$X_e = a + bY$

RESULTS AND DISCUSSIONS:
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 stepof 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.
Minitab software has been used to generate the equation of multiple regression safetymodel and tested the significance of the model through ANOVA (Analysis of Variance). Here only the Lost Time for Incidents are considered.

Table 5: Consequences of the interventions for the analysis

Year 2022	eportable safety issue/Incidents		Recordable Number of Lost Time Incidents				
	Near Miss	MAJ OR FIRE	MINORFIRE	LTA	NLTA	ELEC TRIC SPARK	Total
Month	NM	MF	MF	LTA	NLTA	ES	(MTC+DAFW+RDC+ FAT)
Jan	42	1	1	-	1	1	4
Feb	67	-	-	-	-	-	0
Mar	33	-	-	-	-	-	0 30
Apr	55	-	-	2	2	-	4
May	38	-	1	-	-	-	1
Jun	58				2		2
Jul	43		2				2
Aug	40					1	1
Sep	37				1	2	3
Oct	35		1				1
Nov	36	1	1		1	1	4
Dec	23						0

The developed regression equation is shown in Eq. 2. Hence regression equation is

$$Y = 17.9834 + 1.18116X1 - 1.16739X2 - 1.62623X3 - 0.681564X4 + 0.393113X5 \quad (2)$$

As consequence of the interventions, two different safety issues/incidents and four different Lost Time Incidents issues have been observed in different months and are shown in Table 6.

Table 6: Different safety interventions and the Lost TimeIncidents fordifferent months

Year2022	Safety Interventions (in thousand man-hours)					Total No. Lost Time Incidents. (MJ+MF+LTA+NLTA+ES+FA+SM)
Month	X1	X2	X3	X4	X5	Y

Jan	3	1	1	19	2	4
Feb	3	1	1	26	2	0
Mar	4	1	1	31	3	0
Apr	6	1	1	27	3	4
May	5	1	1	17	3	2
Jun	5	1	1	17	3	2
Jul	7	1	1	24	3	2
Aug	5	1	1	22	2	1
Sep	5	1	1	14	2	3
Oct	31	1	1	35	2	1
Nov	7	1	1	10	3	4
Dec	5	1	0.5	11	3	0

Data for the regression analysis are shown in Table 7. No unusual observations are found and the safety model is significant, as the P value is smaller than 0.05 (for 95%).

Table 7: Distribution of accident types against months

Coefficients						
Term		Coef SE	Coef	T	P	
Constant		17.9834	6.02	2.98	0.024	
X1		1.1812	0.68	1.723	0.136	
X2		-1.1674	0.61	-1.89704	0.107	
X3		-1.6262	0.605	-2.686	0.036	
X4		-.686	0.5263	-1.294	0.243	
X5		0.39	0.497	0.789	0.460	
Summary of Mode						
S		R-Sq	R-Sq(adj)	PRESS	R-Sq(pred) 32	
4.11368		64.12%	34.22%	429.229	-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	181.466	181.466	36.293	2.14469	0.0190020
X2	1	181.466	181.466	36.293	2.14469	0.0190020
X3	1	181.466	181.466	36.293	2.14469	0.0190020
X4	1	181.466	181.466	36.293	2.14469	0.0190020
X5	1	181.466	181.466	36.293	2.14469	0.0190020

Error	6	181.466	181.466	36.293	2.14469	0.0190020
Total	V1	283.000				

Response Surface plot:

From the above mentioned Eq.2, X1(Factor A) and X5(Factor E) are positive which actually contributed to the incident rate. Thus in order to optimize the value of the contributing factors, response surface methodology has been used. Figure 4 representsthe response surface designs depicting the relationship between incident rate and Factors A, and E. 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 regionof increased incident rates (local maximum).

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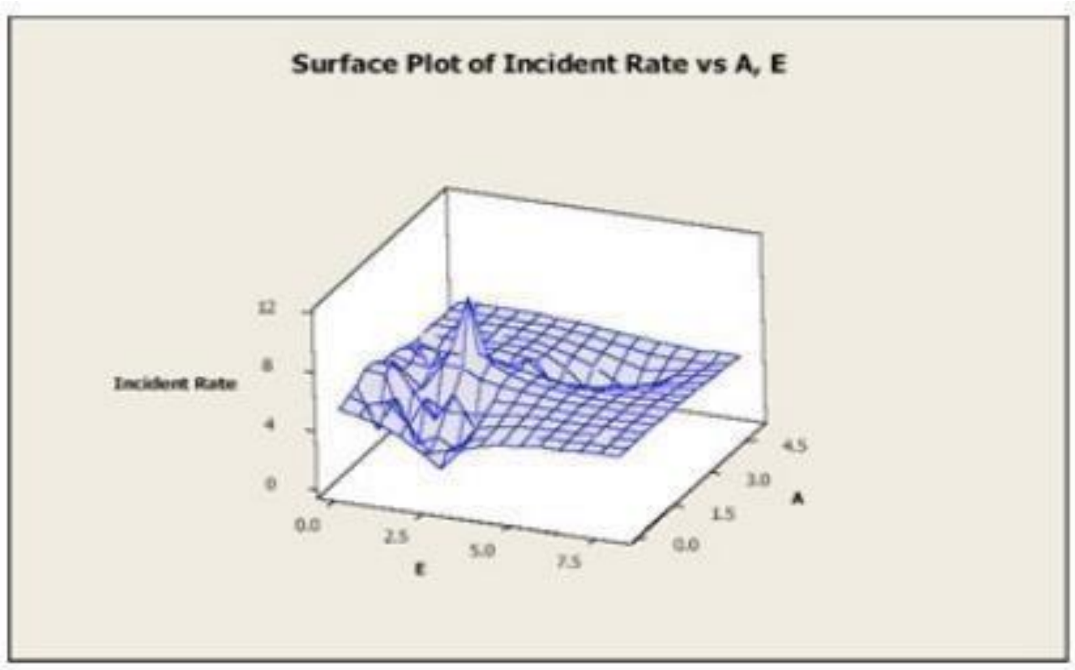

Fig. 4: Response Surface Plot of Incident Rate vs. Factor A and E

The optimum or desirable incident rate (zero) is achieved when the organizationallocates 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 (to 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 FactorE is kept the same at 2.5%. This indicates that the additional allocation of resources towards safety intervention activities do not necessarily minimize incident rate.

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CONCLUSIONS:

A regression model has been developed in order to find out the effect of prominent safetyinterventions on incident rate. It is found from the developed regression model that two of the interventions (Factor A: Leadership and Accountability & Factor E:Evaluation, Measurement and Verification) are mainly responsible for incident rate. These two interventions are further investigated and obtained an optimum resource allocation strategy for incident rate has been obtained.

The strategy is to allocate 1.5% of organization's 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) in order to get an acceptable incident rate.
Furthermore, incident rate rapidly increased when the organization doubles the allocation of its available man-hours or resources from 1.5% to 3.0% to Factor A, butthe allocation of the available man-hours or resources to Factor E is kept the same at 2.5%. Thus, it is concluded that the additional allocation of resources does not necessarily minimize incident rates.

Future Scope:
The problem studied in this thesis may be further extended by considering morefactors for analysis.
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