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IDENTIFICATION OF TECHNOLOGICAL AND HUMAN FACTORS OF INDUSTRIAL ACCIDENTS

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THE goal of this research was to identify technological and human factors of occupational accidents in one of the main oil companies in Iran. The sample of this research was 600 respondents selected by a stratified random method from three sub companies in Ahvaz, Iran. The primary data for analysis were generated through a structured questionnaire. This questionnaire consisted of 137 items, covering all human and technological aspects of occupational accidents. The data were analyzed using the principal component method of factor analysis and the varimax orthogonal. Three major factors, one technological factor and two human factors were extracted. The technological factor was named "Inadequacy of technological aspects" consisting of 40 items with 16.25 percent of the variance. The first human factor was called "Improper execution of organizational processes", which consisted of 71 items with 21.99 percent of variance. The second human factor called "Incorrect implementation of management methods" consisting of 16 items with 9.96 percent of variance.

Keywords: Accident Involvement, Causes of Industrial Accidents, Occupational Accidents, Human Factors, Technological Factors.

Introduction

Since the last few decades while the industry is amazingly prospering towards modern technology, it entailed complicated production techniques inherently associated with many dangers. In the event of an accident the tragedy may cause serious irrevocable damage. It has been observed that industrialization and complexity of industrial activities have raised the serious problems of occupational accidents in the form of industrial hazards or ailments. Such hazards have caused detrimental health impacts, ranging from catastrophic direct effects, like the recent cholera epidemic in Latin America and the chemical poisoning outbreak in Bhopal, India (Bhopal, India 1985 which caused 2,000 deaths and 200,000 poisoned), and Environmental Hazard in Methylisocynate, to chronic effects in Minamqata, Japan, to subtle, indirect, and disputed effect in Love Canal tragedy in the USA, as Acute Lung Disease.

We have taken up this upheaval task as a challenge in the interest and benefit of the individuals, the society, the organization and ultimately the society.

In this research, the purpose was to identify the major factors causing the accidents.

The significant fact is that accidents affect every country of the world, but it is the poorest countries where people most frequently lose their lives.

Above all, to evaluate the magnitude of the problems, it is revealing to learn that in today's world

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accidents cause more deaths than any single illness. The losses due to the industrial accidents are phenomenal and call for immediate attention of the scientists, engineers, doctors, psychologists, social thinkers, industrialists, managers, etc. to address the situation for the salvation of human sufferings.

Despite this worrying situation, international awareness of the magnitude of the problem remains surprisingly modest. The inadequate dissemination of knowledge and information hampers action, especially in developing countries. It also limits the capacity to design and implement effective policies and programs. To reduce the human suffering and financial loss associated with these risks, there is a need for increased and sustained action to protect occupational health and safety, and the environment.

The researchers aim was to study the human and technological characteristics related to the accident involvement and to identify technological and human factors responsible for the occurrence of accidents.

The purpose of this research was (1). To identify the causes of industrial accidents in the Oil Industry in Iran, (2). To make the necessary suggestions and recommendations for the prevention of accidents.

Research Questions

In this research following questions have been studied.

1. Which technological factors causes industrial accidents?
2. Which human factors causes industrial accidents?

Literature Review

In the past, to achieve the goals of reducing occupational injuries and illnesses and promoting occupational safety and health have been characterized as the "three E's": engineering, enforcement and education. The three are interdependent and receive varying levels of emphasis within different national systems. Today, researchers have considered the Human factors, too.

According to the "domine theory" of where the contributing factors can be grouped into the following two categories:(1) Behavioural which includes, lack of knowledge, lack of skills and inadequate physical and mental condition. (2) Environmental which includes, improper guarding of other hazardous work elements and degradation of equipment through use and unsafe procedures. Although, this does not have any foundation in psychobiology, the biorhythm theory has attracted the interest of some safety practitioners. The theory suggests that the percentage of accidents occurring on 'critical days' (days on which 'cycles' of intellectual, emotional, and physical capacity change) will be much higher than the percentage occurring on other days.

Asange, (1988), suggests that human reliability parameters are most varied, unpredictable and some what puzzling in nature, such that research in human behavior under various stresses and environmental conditions presents a wide field of investigation and tend to involve the realms of human psychology and physiology.

The criterion typically used in accident research is the number of accidents incurred over a period of time. In most cases, the accident has produced over a personal injury. Some studies have used alternative measures such as number of "near misses" and supervisors' ratings of safety performance. One of the reasons for doing this is to increase the variability of the criterion. In the typical study that covered a brief period of time, most of the subjects had no accidents, some had one accident, and very few had more than one. This extremely skewed distribution caused problems when attempting to use correlation statistics (Arbous and Kirrich, 1951). This study sough to minimize this problem by developing a composite measure of accident behavior. The accident consistency variable was the number of accidents incurred by an individual plus the number of years that the employee incurred at least one accident.

Each of these measures has been used separately in past research (Hansen, 1988). It is proposed that this composite variable reflects the "consistency" of one's accident tendency by adding a measure of temporal frequency (number of years with an accident) to a measure of quantity (number of accidents).

This measure is the best criterion for a causal study because a major outcome concern is the prediction of accident potential for as long as possible. A worker who had a clean record except for four accidents in 1 year may simply have had an a typical year because of situational problems. That individual would be a relatively "poor bet" to consistently have accidents in the future. On the other hand, the employee who had one accident in each of 4 years could be demonstrating a personal propensity to have accidents at a low rate in the future Both he short, and long-term implications of each worker's accident record are important, although a company would have better success in identifying and intervening with the later worker.

Sanders and McCormick (1993), says that human factor researchers have, therefore, studied such variables as workers energy expenditure, strength, endurance, speed, accuracy of movements, and workload. Knowledge gained through this research has promoted the design of work places that maximize human performance, and minimize such outcomes as fatigue, stress, and the errors to which they contribute. He argued that it is often easier to design a safe workplace rather than to make workers behave safely, but workers must learn to use their work equipments, and by, doing so are likely to make errors and have accidents.

The relationship among industrial accidents, personality traits and cognitive characteristics has been intensely studied since the early 1900s (Hansen, 1988). Most of the research has sought to identify worker characteristics that differentiate between the employees with and without accidents.

Most people are not aware of their general vulnerability during periods of intense stress (see Levenson, 1980). For example, it may be commonly recognised that stress is associated with sleep loss, but it is not so well recognised that sleep loss is associated with industrial accidents.

According to the pure chance theory, every one of any given set of workers has an equal chance of being involved in an accident. It further implies that there is no single discernible pattern of events that leads to an accident. In this theory, all accidents are treated as corresponding to Heinrich's acts of God, and it is held that there exist no interventions to prevent them (Stellman, 1998).

Those who accept the energy transfer theory put forward the claim that a worker incurs injury or equipment suffered damage through a change of energy, and that for every change of energy there is a source, a path and a receiver. This theory is useful for determinating injury causation and evaluating energy hazards and either preventive, limiting or ameliorating with respect to the energy transfer (Stellman, 1998).

The "symptoms versus causes" theory is not as much a theory as an admonition to be heeded if accident causation is to be understood. Usually, when investigating accidents, we tend to fasten upon the obvious causes of the accident to the neglect of the root causes. Unsafe acts and unsafe conditions are the symptoms-the proximate causes-and not the root causes of the accident (Stellman, 1998).

Accident proneness theory maintains that within a given set of workers, there exists a subset of workers who are more liable to be involved in accidents. Researchers have been able to prove this theory conclusively because most of the research work has been poorly conducted and most of the findings are contradictory and inconclusive. This theory is not generally accepted. It is felt that if indeed this theory is supported by any empirical evidence at all, it probably accounts for only a very low proportion of accidents without any statistical significance (Stellman, 1998).

In theory, it is possible that a safety first campaign might by explanation and education affect every individual in the same manner. Everybody remains equally accident prone although less prone to have accidents. Again, everybody "learns by experience", and it is possible mathematically if not psychologically for everybody to learn alike (Stellman,1998).

Education focuses on theory or principles. Training gets into the specification of how to turn principles into effective action (Geller, 2001).

McKenna (1978), McKenna and Hale (1982) have all reported that the main effect of first aid training is to facilitate a more rational attitude towards responsibility allocation. In turn, this probably affects individuals' motivations to eliminate perceived hazard. Kjellen and Baneryd (1983) reported that worker discussion groups also facilitated greater individual acceptance of responsibility for safety, and this suggests that safety programs might be directed more towards encouraging individuals to see safety as a matter of personal responsibility. What is implied here is more than simply changing people's attitudes towards safety.

The overall rationale for training and education is to improve awareness of safety and health hazards, to expand knowledge of the causes of occupational illness and injury and to promote the implementation of effective measures. The specific purpose and impetus for training will, however vary for different target audiences.

"Designing for everyone" puts special emphasis on an ergonomic approach that is based on the characteristics and capabilities of the worker, a concept often overlooked in practice. The ILO Encyclopedia are directly related to ergonomics, such as Heat and Cold, Noise, Vibration, Visual Display Units, and virtually all chapters in the sections, Accidents and Safety Management and Management and Policy (Stellman, 1998).

Reber and Wallin (1983) suggesting that it is essential to tackle safety at both behavioural and attitudinal levels.

According to Alice H. Suter, Noise is one of the most common of all the occupational hazards (Stellman, 1998).

According to Thomas J. Nelson, In some Industries, air contaminated with potentially harmful dusts, fumes, mists, vapors or gases may cause harm to the workers (Stellman, 1998).

Kimuro claims that eye and face protection includes safety spectacles, goggles, face shields and similar items used to protect against flying particles and foreign bodies, corrosive chemicals, fumes, lasers and radiation. Often, the whole face may need protection against radiation or mechanical, thermal or chemical hazards. Sometimes a specific eye protection is necessary, either separately or as a complement to the face protection (Stellman, 1998).

Miura states that injuries to foot and leg are common to many industries. The dropping of a heavy object may injure the foot, particularly the toes, in any workplace, especially among workers in the heavier industries such as mining, metal manufacture, engineering and building and construction work. Burns of the lower limbs from the molten metals, sparks or concessive chemicals occur frequently in foundries, iron-and steelworks, chemical plants and so on. Dermatitis or eczema may be caused by a variety of acidic, alkaline and many other agents (Stellman, 1998).

According to Balty and Mayer, head injuries are fairly common in industry and account for 3 to 6% of all industrial injuries in industrialized countries (Stellman, 1998).

Manasdorf asserts that there are general categories of bodily hazards for which specialized clothing can provide protection. These general categories include chemical, physical and biological hazards (Stellman, 1998).

Nelson contends that in some industries, air contaminated with potentially harmful dusts, fumes, mists, vapors or gases may cause harm to the workers (Stellman,1998).

Researcher hope to avert some of the forthcoming tragedies caused by industrial accidents influencing the humanity in general and society and individual in particular. The study here is proposed to identify the technological and human factors due to which accidents occur in oil industries.

Methodology

The population of this research consisting of employees of the three subsidiary companies of a major oil company, in Ahvaz, Iran. For this purpose, first two groups accident victims were selected randomly to provide the particular causes of accidents in these companies. Researches, through interview and written query, prepared a list of 177 technological and human causes of the accidents. A revision of this list by the researchers and a sample of 50 managers of the these subcompanies reduced the items of the list to 137. The revised list was used as the questionnaire for this study. The sample consisted of 724 (220 victims and 504 non-victims) employees, selected by a stratified random method from the population of each of three companies.

This questionnaire was completed by 600 out of the 724 (about 79%) employees serving as the sample of study (Table 1).

Table 1: Frequency of Chosen Sample and Frequency of Responded Applicants

	Frequency of Total Region	Chosen Victim	Sample Non-victim	Frequency Non-victim	of Victim	Responded Absent	Applicants Total Joined
Company No. 1	334	91	243	161	123	50	284
Company No. 2	211	56	155	119	43	49	162
Company No. 3	173	73	100	85	69	19	154
Total	718	220	498	365	235	118	600

Table 2: Descriptive Statistics of Total Sample in Nisoc

	N	Range	Mini-mum	Maxi-mum	Mean		Std. Dev.	Skewness		Kurtosis	
	Stat.	Stat.	Stat.	Stat.	Stat.	Std. Er.	Stat.	Stat.	Std. Er.	Stat.	Std. Er.
AGE	490	35	25	60	10.6	.67	16.39	-1.33	.100	.90	.199
Education	503		3	18	11.1		4.06				
Experience	494	38	3	41	22.9	.44	10.67	-.27	.100	-.72	.199

Data Analysis

The data collected were analyzed by applying the principle components method of factor analysis, using varimax type of orthogonal rotation methods.

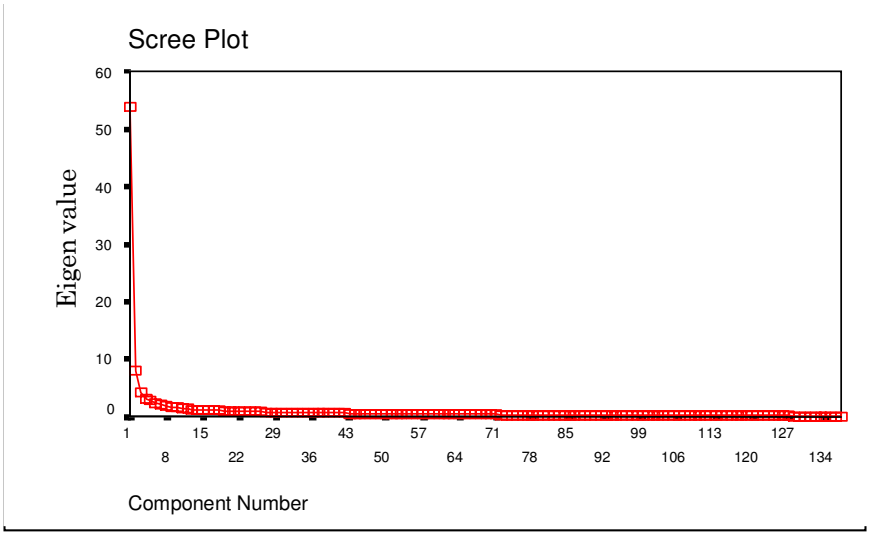
Multiple Regression Analysis

To assure the appropriateness of the data collected for factor analysis, tests of KMO and Bartlett were used. KMO index was .974 and Bartlett's test yielded a x2 = 66778.88. Both indices are completely satisfactory.

Findings

In relation with ability of 137 designed questions, for doing Factor Analysis, KMO test have been used. The consisted Factor Analysis also is for shortened the questionnaire in main factors. To followed Factor Analysis, the KMO, Bartlett's Test of Spercity-Klpan Meir has been used.

To deforming the number of factors to be extracted Cattell's Scree test was used. The scree test is shown in Diagram 1.



On the basis of the scree diagram, three factors were extracted. The cut-off point of .45 was set to determine the number of items in each of the three factors. These factors along with their eigenvalues, percents of variance explained cumulative percents of explained variance, number of iems in each factors, means and standard deviations of the three factors are shown in Table 3.

Table3: Mean, Standard Deviations, Eigen Value, % of Variance, and Cumulative (600)

Factor No.	Mean	Standard Devation	Rotation Sums Total (Eigen Value)	of Squared % of Var.	Loading Cuml. % of Var.	Number of Items
1	29.4	16.39	30.13	21.99	21.99	71
2	11.05	4.06	22.27	16.25	38.24	40
3	19.98	10.67	13.65	9.96	48.21	16

According to table 3, the values of the above indices for the three factors are as follows.

Factor One, (x=29.4, S.D=16.39, EigenValue=30.13, % of Var.=21.99, Cuml. var.%=

21.99 and 71 items), *Factor two* (x =11.05, S.D=4.06, EigenValue =22.27, % of Var.=16.25, Cuml. var. %= 38.24 and 40 items), *Factor three* (x =19.98, S.D=10.67, *EigenValue* =13.65, % f Var.=9.96, Cuml.

var.%=48.21 and 71 items). The numbers of items included in the three factors are as follows: factors 1, 71 items, factor 2, 40 items, and factor 3, 16 items.

The factors were labeled after a careful serenity in the items comprising, each of the three factors. Thus, the three factors were labeled, respectively, as follows:

1. "Improper Execution of Organizational Processes",
2. "Inadequacy of Technological Aspects",
3. "Incorrect Implementation of Management Methods".

Table 4: The Reliability Table

Statistical Index			**Reliability**		
Kind	**Factors**	**Correlation Between**	**Spearman Brown**	**Gutt man Split-Half**	**Alpha Cronbach**
Total	F1(71)	0.95218	0.9593	0.9579	0.9862
Sample	F2(40)	0.828	0.9059	0.9045	0.97
	F3(16)	0.7678	0.8686	0.8681	0.9445
Accident	F1(67)	0.9247	0.9609	0.9595	0.9858
Involved	F2(42)	0.8157	0.8985	0.897	0.9703
Sample	F3(23)	0.8047	0.892	0.8914	0.9566
Non-Accident	F1(73)	0.9223	0.9594	0.9594	0.9865
Involved	F2(34)	0.842	0.9142	0.9131	0.967
Sample	F3(9)	0.7796	0.8773	0.8709	0.904

As Table 5 and Table 6, show, in total sample (600). Factor Loading for each variables have been arranged as decreasing absolute value as concerned minimum Factor Loading of 0.45. The variables less than 0.45 has been deleted. So from total 137 recognized original questions, 10 variables has been deleted. The Factor Analysis depicts 10 of obtained variables were not related to accident involvement.

Results and Discussion

The goal of this research was to identify the factors causing industrial accidents in Oil Industry of Iran. To reach this goal principal component factor analysis was used. The three "Improper Execution of Organizational Processes", "Incorrect Implementation of Management Methods" and "Inadequacy of Technological Aspects". Two of the factors, that is, "Improper Execution of Organizational Processes" and "Incorrect Implementation of Management Methods" are human factors which are also in harmony with the indings of other researchers such as Hansen (1989), and Foreman, Allis, and Beavan, Lavie, Kremerman and Wie (1982), Smith and Kirkham (1981), and Stellman (1998). The obtained factor show that a major part of industrial accidents are due to the problems and difficulties of employees in the organizations. The third factors, that is, "Inadequacy of Technological Aspects" is due to technical variables.

Comprehending why technological variables cause accidents is not very difficult; non-standard tools, machines and equipments, shortage of safety and protective tools and equipment, or non-observance of safety measures are the probable causes of accident occurrences. But comprehending how human

variables cause accidents can be explained by several general reasons.

One explanation for the effects of human variables on causing industrial accidents is the different problems with which the manpower may be involved. These problems will occupy the minds of the employees, and facilitate the occurrence of accidents.

This mind-boggling will cause absent mindedness and mental distraction, as well as lack of concentration on the job that affect the performance of the work.. The result will probably increase their accident involvements. The problems and difficulties of manpower in organizations come from two major sources.

(A) The first source is related to personal and individual characteristics and psychological or physical movements of the employees. This means that the employees of an organization may not have the potential, the ability, the personal characteristics such as rhythm and harmony of the eyes and the hand/foot, or enough flexibility of the limbs involved in doing a job , etc. If this is true, engagement of manpower in accidents will be anticipated. Manpower also needs the necessary knowledge, experience and skill for doing jobs. Shortage of this characteristic probably will increase the cause of accidents' involvement for manpower, and will increase accidents' occurrence. (B) The second source will be the problems in the work area, or out of the work area, in addition to the family problems. Problems such as, job dissatisfactions, feeling of injustice and discrimination, arguments with supervisors, colleagues and employees which are mind-boggling and will make them prone to accidents.

Negative attitudes to safety and absence of motives to observe safety regulations will also cause the involvement of the manpower in accidents. If there is a risk of negative attitude in the organization and the manpower shows inclination toward a risky behavior, and if, there is not enough motivation for safe behavior in accordance with safety rules and regulations, the occurrence of accidents in the organization will be certain.

As it is seen many different factors may cause the engagement of the manpower in occupational accidents. So, an organization's executives and safety managers should consider these factors and plan to prevent such accidents in the organization and provide a safe environment without danger or risk.

Safety recommendations on the basis of research findings.

The goal of this research is to identify causes of industrial accidents in Oil Industries, and to suggest proper measures and recommendations for the prevention of accidents. For this reason, variables of each one of the three obtained major factors require careful study to arrive at solutions. Here some of important categories will be suggested as follow:

A. Improper Execution of Organizational Processes

By studying the consisting variables of the factor "Improper Execution of Organizational Processes", different improving categories may be suggested as follows:

1. Friendly relationship of supervisors and managers with their personnel.
2. Providing enough actual work trainings for different personnel in different jobs and duties.
3. Relieving personnel from fear threats and existence of stress problems in work areas.
4. Matching of jobs' physical characteristics with employees' characteristics.
5. Providing safety culture in the work place.
6. Providing job satisfaction and motivation for employees from different aspects of/ reatment by their work.

7. Offering equal opportunities to the personnel. (Providing justice and fair supervisors and managers.
8. Providing suitable human models for the personnel to follow work safety regulations.
9. Solving personnel problems in relation with their family problems.
10. Reducing long time overtimes.
11. Providing suggestions channels to receive employees' suggestions.
12. Preventing work fatigue.

B. Inadequacy of Technological Aspects

1. Attendant of safety and fire extinguishing officials in accidents' place on time.
2. Offering suitable skill and safety trainings corresponding to the work conditions.
3. Encouraging employees to use safety /protective facilities.
4. Providing suitable needed facilities to extinguish fire.
5. Providing standard parts, tools, equipments, machines and safety cloths.
6. Regular service and maintenance, control and inspection of machines, tools, and equipment by responsible people on work.
7. Replacing worn transferring pipes of gas and gasoline.
8. Providing medical facilities on site of work/operation with high accident risks.
9. Standardizing roads used for related work of oil industries.
10. Providing suitable standard distance and space between machines and equipment.
11. Execution of high risk tasks without haste on irrational speed.

C. Incorrect Implementation of Management Methods

1. Solving problems of the personnel dwellings and financial problems.
2. Removal of discrimination and unbiased assessment in the organization, such as giving advantages, financial benefits, raises, etc.
3. Use of participative management.
4. Providing a suitable system of reward and punishment.
5. More consideration and care of managers and supervisors for their personnel problems, suggestions, and talents of employees and taking proper steps toward them.

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