Evaluating Occupational Accidents and Their Indices In a Refining and Distributing Company of Petroleum Products of Mahshahr 2008-2010

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ABSTRACT

Technological progress and oil industry development accompanies have a high rate of risk. This study was conducted with the aim of evaluating occupational accidents and related indicators for decreasing the number of damages by offering control measures.

In this descriptive-analytical study, essential information was extracted from the records and agendas of the technical safety committee and the evaluation of accident frequency was done based on the accident type, the time and the location of its occurrence, environmental condition, root factors, and demographic variables of the injured. The relationship between repetition, severity, frequency of the accidents and marital status of the company's personnel was also studied. Accident analysis was done by Chi square test .

The occurrence of about 102 accidents was reported in an incident evaluation, which was done between the years 2008 and 2010. The average age of the injured was 29.1± 8.61. Accidents and clashes were 31.4% of the accidents and falling from height 21.6% of them. Many of the accidents occurred in plumbing activities (24.5%), tank construction (23.5%), and civil operations (15.7%). 47% of the accidents happened in 2009, 43% in 2010, and 10% in 2008. Occurrence rate of accidents was 48.1 and their intensity rate equaled 0.15 for one million working hours. The relationship of accident type and marital status was a meaningful relationship based on Chi-square test ($P = 0.014$); this test showed the relationship of accident type and its reasons a significant one as well. ($P = 0.035$)

Considering the calculated coefficients and evaluated factors in this study, safety training, constant inquiring of sub-activities, inserting safety and HSE provisions and guidelines to the contractors' contracts and monitoring their application would be effective in decreasing the number accidents. .

Key words: Accident, petroleum, Incident, Occupational, Severity

LIST OF ABBREVIATIONS

- Accident Frequency Rate (AFR)
- Accident Severity Rate (ASR)
- Incident Rate (IR)

INTRODUCTION

Although technology and industry development has positive and invaluable effects, associating negative and unpleasant effects are sometimes observed; some negative effects like occupational accidents, an increase in the quantity and quality of pollution caused by industrial and residential environments, and work-related diseases, threatening the lives of the people more than past [1].

Every year, millions of people become disabled due to occupational accidents. This issue causes the loss of the active workforce and millions of efficient working hours [2]. Most of the people (58%) spend one third of their adulthood in environmental work [3].

Based on the present data, occupational accidents are considered as the third reason for death in the world and one of the important health, social, and economic factors in industrial and developing countries [4].

Many of workers suffer from missing some working days, not having medical cares, losing consciousness, action limitation, and/or changing job because of occupational accidents [1]. Recognizing the reason for such accidents is one of the vital and basic measures to control and decrease subsequent damages. These kinds of reasons can be

understandable in specific cultural, social, and economic context of each society [5].

Based on item 60 of Social Security Law, occupational accidents are those accidents which might happen to the insured staff while they are on their duties. This means that an occupational accident includes any event that might happen to an insured staff while working at his/her office, its premises and other related divisions. Additionally, it comprises any accident which might occur when a worker is on a mission assigned by employer or during commuting time from home to work and vice versa. Moreover, accidents which might happen while attempting to rescue other injured persons could be considered as work injury [6].

Miller *et al.*, carried out a number of studies on occupational accidents and their financial consequences with quantitative models. They have found that, accident prevention is one of the determinant factors for decreasing the financial expenses due occupational accidents and increasing efficiency rate of staff [7].

Juan Manuel Parejo-Moscoso and his colleagues in a study with the aim of reviewing occupational accidents in an olive oil company in Spain have concluded that slides, wrong body movements, and falling from height are respectively the most frequent accidents with 14.86, 13.51, and 12.2 percentage points. In that study, the amounts of Incidence Rate (IR), Accident Frequency Rate (AFR), and Accident Severity Rate (ASR) were 3.83, 21.25, and 0.99. The researchers of that study came to this conclusion that their study might facilitate the implication and execution of administrative systems for augmenting the organization's efficiency through authorities' decisions [8].

By studying occupational accidents with the help of data collection, facts, and accidents' real causes, nature, type, realm, and harm range of them can be determined. Similar accidents can be prevented by knowing the reason and the way of accident occurrence. In addition, studying accidents can be considered as a basic element in danger control; in fact, without a research system and a comprehensive record of accidents and their subsequent damages, the administration would not be able to have reliable knowledge over the conditions which cause efficiency fall in duty fulfillment.

Since in the manufacturing stage and in the start-up stage the activities have a certain amount of intensity and dispersion, the type of the activities, and work groups are changing. Moreover, the personnel with a variety of cultures have limited job backgrounds, and safety rules are not correctly executed; therefore, there would be a rise in the accidents frequency. That is to say, evaluating harms and damages caused by occupational accidents, collecting relevant data and analyzing them are basic primary steps for accident control and pre-preparation for facing accidents. Without complete information about the basic reasons for accident occurrence and their results, the authorities would not be able to make conscious decisions for controlling accidents. Thus, this study was conducted with the aim of evaluating occupational accidents and the related indicators in an Oil Refining and Distribution Company of petroleum products of Mahshahr in 2013 for the authorities and safety officials to utilize its results in offering and recommending proper solutions and control measures.

MATERIALS AND METHODS

This descriptive-analytical study was done on the injured from 2008 to 2010. In this research, working hours, missed working days, severity rate, frequency rate, and other demographic variables were evaluated. After making required arrangements with the authorities and creating a team/ board of senior managers, technicians, foremen, and occupational health experts, discussions were held, in which the ways of researching for better affectivity were mentioned. Afterwards, essential primary information was extracted from the records and agendas of the technical safety committee. To find out some more required information, the injured and witnesses were also interviewed using practicing recalling technique. Incident, severity and frequency rates were estimated based on the criteria of American National Standard Institute with formulas and the data gained from primary analysis; besides, for permanent disability, death, or maim, accident severity rate was calculated based on the tables of lost working days by the harm type through following formulas [9,10].

$$AFR = \frac{Number\ of\ accidents}{Number\ of\ work\ hours\ in\ 2008-2010} \times 1000000$$

$$IR = \frac{Number\ of\ accident\ in\ 2008-2010}{Average\ nuber\ of\ the\ at\ risk\ workers} \times 1000$$

$$ASR = \frac{Number\ of\ work\ days\ lost}{Number\ of\ work\ hours\ in\ 2008-2010} \times 1000000$$

For each type of injury or disability, there are certain numbers of working days, which are attainable by special tables. Furthermore, according to the Worker International Statistics Conference, in 1974, the number of wasted days of each worker's death equals 7500. Industrial safety and immunity experts believe that, if the accident severity rate is below 1 in a factory or workshop, that place is good in terms of observing safety rules.

The results showed amount of the formula of accident frequency rate indicates that, there are always some injured workers per 1000 working hours in an organization; it also shows the fact that how frequent the accidents are per 1000 working hour. In this study, after data collection, the information was inserted into SPSS-Ver. 19, and accident frequency distribution was calculated based on the causes and marital status of the workers; accidents analysis was done by Chi Square Test.

RESULTS

As the results of the study show, average age of the studied individuals was 8.61 ± 29.11, and the range of their age was between 20 and 59 years. 80% of the injured were in the age range of 20 to 34 years. The education level of 72% of the injured was under diploma, 67.3% of whom were local people. 52.9% of the injured were married, and the average job background of them was 6 ± 6.6 with the range of 1 to 26 years. 49% of the injured had the job background of less than 2 years, and 28.4% of them had the job background of 3 to 10 years. 24.5% of the accidents happened in the plumbing location, 23.5% in the tank manufacturing place, and 15.7% of them at the location of civil operation. 37.2% of the accidents happened in the scope of the tanks, 35.3% of them in the scope of the buildings, and 18.6% of around workshop equipment. Based on the findings, 47.05% of the accidents happened in 2009, 43.13% of in 2010, and 9.8% of them in 2008. The highest rates of accident frequency respectively went to months October, December and January with 13.7%, 10.8%, and 9.8%. On the hand, only 2.9% of the accidents, the least number of them, happened in Farvardin. It should be noted that, no considerable difference was seen among a month's days in terms of accident frequency. In 94.1% of the accident cases, weather condition was fair and fine. Generally, the most important reasons for the accidents at Mahshahr Oil Refining Company were collision with objects and machinery (with 31.4 percentage points), falling from height/ tumbling (with 21.6 percentage points), and transportation accidents (with 11.8 percentage points). Objects crash and Falling down, each with 8.8 percentage points are in the next levels.

As it is shown in table 1, 53% of accidents happen due to unsafe and dangerous actions, and 27% of them because of unsafe and dangerous conditions; while, improper organizational structures and administrative factors cause 22% of the occupational accidents.

Table 1: Frequently distribution of accident kind based on the causes, in the personnel of Mahshahr Oil Refining Company, 2008-2010

Accidents' causes	Structural and administrative		Unsafe action		Unsafe conditions	
Accident type	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
collision	4	18.2	25	47.2	2	7.4
Falling from height	7	31.8	7	13.2	9	33.3
Transportation	3	13.6	5	9.4	4	14.8
Falling down	0	0	5	9.4	4	14.8
Objects crash	3	13.6	2	3.8	4	14.8
Others	5	22.7	9	17	4	14.8
Total	22	100	3	100	27	100

Chi-square=22.2, df = 10, p=0.014

Based on table 2, severity rate of the accidents was ascending from 2008 to 2010 (26.1%, 46.2%, and 63.2%), and based on the calculated and recorded severity rates in the 3 years (0.02, 0.13, and 0.24) and the incident rate in the company has been increased.

Table 2: ASR and AFR amounts in Mahshahr Oil Refining Company, 2008 - 2010

Variables year	Personnel Operation (person_ hour)	Frequency of accident	Lost days	Duration rate	AFR	ASR	IR
2008	382290	10	8	3829	26.1	0.02	52.3
2009	1039110	48	135	27648	46.2	0.13	92.3
2010	696240	44	169	15823	63.2	0.24	126.4
Total	2117640	102	312	757000	48.1	0.15	96.4

Evaluating accident frequency in 1000000 working days in those 3 years showed that, accident frequency by person-working days has increased from 209 in 1 million to 506 in 1 million. AFR means that, for instance in 2008, there were 26.1 accidents per 1 million working days. This factor's amount was 46.2 and 63.2 for the years 2009 and 2010. The overall amount is 48.1 accidents for

the 3 years. ASR on the other hand indicates the average number of missed days out of 1000 working days in 2008, 2009, and 2010, that were 0.02, 0.13, and 0.24 days, respectively. The results of this study proved that, there has been one accident per each 75700 working hours. Duration rate is the personnel's person-working days for an accident, the amount of which was 38229 in 2008 and 15823 in 2010.

Based on table 3, most of the accidents have happened in testing and mapping, tank manufacturing, workshop equipping operation, and plumbing, while the least number of the accidents have occurred in cabling operation, blast operation, coloring, covering, and construction and installation of metal structures. In terms of incident severity, the highest amount relates to plumbing (0.4), tank manufacturing (0.3), and workshop equipping (0.14).

Table 3: Indexes rate at project activities of Mahshahr Oil Refining Company from 2008 to 2010

Variables Project activities	Personnel Operation (person_hour)	Duration rate	Accident frequency	AFR	lost workdays	ASR	IR
Workshop equipping	36421	12140	3	82.37	5	0.1372	164.7
Preparation & plat form consolidation	145683	29137	5	34.32	3	0.0205	68.6
Civil operation	536572	33536	16	29.18	43	0.0801	59.3
Building construction	233005	19417	12	51.5	22	0.0944	103
Construction & installation of metal structures	132703	66351	2	15.07	14	0.1054	30.1
Plumbing operation	333523	13341	25	74.95	134	0.4017	149.9
Tank manufacturing	286995	11958	24	83.62	86	0.2996	167.2
Mechanical equipment installation	28889	28889	1	34.61	2	0.0692	69.2
Sand blast & coloring	224242	74747	3	13.37	2	0.0089	26.7
Building installations & ventilation	15384	15384	1	65	0	0	130
Testing & mapping	36421	9105	4	109.82	1	0.0274	219.6
Regulatory & administrative activities	182103	30350	6	32.94	5	0.0274	65.8

Based on the evaluations by Chi square test, there was a statistically meaningful relationship between the personnel's marital status and the accident type (p= 0.035); that is, the accident percentage for single people was 39.6%, while it was 22% for the married ones. The amount of transportation accidents for the single staff was 2.1%, while it was 20.4% for the married people. On the other hand, the frequency of falling accidents in single workers was half of the married ones. Comparably, the occurrence of objects tumbling events among single personnel was two times higher than that of married subjects. (table 4).

Table 4: Accident type frequency in terms of marital status of the personnel of Mahshahr Oil Refining Company from 2008 to 2010

Marital status	Single		Married	
Accident type	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Collision	19	39.6	12	22
Falling from height	10	20.8	13	24.1
Transportation	1	2.1	11	20.4
Falling down	3	6.3	6	11.1
Object tumbling	6	12.5	3	5.6
Others	9	18.8	9	16.7
Total	48	100	54	100

Chi-square=11.99, df =5, p=0.035

As the findings of the present study show, falling accidents happened 2.5 times more for the personnel with education level of diploma and higher, but in general, incident frequency among less literate people was higher than incident frequency among the personnel with higher levels of education. 15.9% of transportation accidents have happened for local people, while only 3% of such accidents have occurred for non-local people. In addition, the results indicated that there is a meaningful and significant difference between age and job background of the individuals in terms of accident type ($p< 0.05$). Furthermore, a meaningful difference was observed between accident type and accident causes; that is, 80% of the causes for collision accidents relate to unsafe actions, and structural and administrative factors don't play a role in falling accidents. More than 30% of the reasons for falling accidents rooted in structural and administrative factors and 33% of the reasons for such accidents related to unsafe conditions.

DISCUSSION

In this study, average age of the injured was 29.1, the age range of them was from 20 to 59, and workers who were younger than 18 years old were not allowed to work in the project; such findings are compatible to the findings of MohammadFamm [11]. It was found that, 80 percentage points of the accidents happened in the age group of 20 to 34. In a study by Vazirinejad, the highest frequency of accidents was proven to be in the age range of 25 to 29 [12].

Nearkesen Chau found that most of the accidents in the area of construction happen for those who are 30 to 39 years old [13]. Suchomel Jozef proved that most of the accidents happen for those who are 26 to 30 years old [14], and in Venezuela, Sirit-Urbina and Fernández-D'Pool exclaimed that most of the accidents happened for the people who were 20 to 29 years old [15]. One of the reasons for high frequency of accidents in this age group could be the tendency of young workers towards difficult work for earning more money; it should be taken into account that, a noticeable percentage of the active population is in this age group.

The average amount of job background of the injured people was 6 ± 6.6, and its range was from 1 to 26 years. In the study by Sirit-Urbina and Fernández-D'Pool, the majority of the accidents, (49% and 28.4%, respectively), was found to be related to the group with less than 3 years of work experience and to the group with 3 to 10 years of work experience [15].

In a study by Suchomel Jozef in Slovakia, it has been mentioned that, the highest frequency of accidents is related to the people with job background of 6 to 10 years (%17), and then, in the second position, to the people with job background of less than 3 years (%14) [14].

In this study, 52.9% of the studied people were married. Investigating occupational accidents from 1380 to 1384, Bakhtiari exclaimed that 20% of the accidents had happened for the single workers and 80% of them for the married ones [16]; this finding is matched with the results of the present paper. In this research, 74.5% of the accidents went to the people with the education level of lower than diploma, 19.6% of the accidents happened for those who had diploma, and 5.8% of the accidents related to the people with higher levels of education.

Suchomel jozef [14] divided the participants into two groups with preliminary and academic education, and proved that 60% of occupational accidents happened in the former; this result is confirmed by the present study. In this study, those with diploma and less than diploma education level dealt with very hazardous activities, and those with higher education were in charge of regulatory and administrative activities and had more knowledge over professional and safety issues. The most important accidents in the workers of warehouse construction related to collision with objects and machinery (31.4%), falling from height (21.6%), and transportation accidents (11.8%).

Investigating construction accidents for two years, Narkasen Chau [13] found that 23.5% of the accidents are falling from height and 8% of them are transportation accidents. In the context of Yazd, Mehrparvar [17] also exclaimed that 25% of the accidents are collision with objects, and 21% of them are falling from height. A part of these differences could be due to the absence of a coherent record system for occupational accidents.

One of the factors fundamentally contributing to the accidents in this study was a collision with machinery, for preventing of which essentially measures like decreasing intensity at work environments, preventing active crowd in some spots, and determining highly dangerous scopes should be applied.

Falling from height is the most frequent type of accidents in most of the construction projects, and working at height requires special professional and skill and has more strict rules. Periodic professional training courses, daily inspection of equipment and facilities, controlling working at height and reducing unnecessary activities from it, and personnel check in terms of skills and physical abilities are recommended.

37.2% of the accidents happened around tanks. In this scope, operations of loading and unloading of plumbs, pre-assembly, construction and installation

of product pipes, transportation of tools and materials, construction of tanks' walls, ceiling, and pillars, and installation of equipment were done. Doing more field studies on such activities could show the high intensity of the activity and its workload, which increase the number of human mistakes and inspection errors and decreases the influence of control measures.

It was found that, least of the accidents happened in March. Records and evidences suggest that, there is a decline in the workforce at that time due to New Year's holiday, and since that time is the end of the financial year, some employers have finished their work; besides, at that time, some employers were in the midst of recruiting new workforce. On the other hand, most of the accidents happened in January (13.7%) and December (10.8%). Incidents frequency in the first half of the year was 39.2%, and in the second half of the year was 60.8%. A rise in the workforce and workload in the second half of the year could be a reason for the high number of accidents in that time.

In 2009, incidents frequency rose by 77%, and its amount reached 369.6 cases out of 1000000 person-working days. Inquiries revealed that, the reason for this rise was the start of extremely risky activities. Decline in accident indicators in this study is in contrast with the results of Hamidi's study [18].

In the present study, the highest accident rate was belonged to the Testing & mapping project activities with a frequency rate of 109.8 in one million person hours and duration rate of 9105 person-hours.

The reason is, these experiments have been executed by personnel throughout the work steps, and most of these activities have been performed at high scattering, with crossing over dangerous and inappropriate regions. Considering the fact that the subjects work at different administrative and executive activities, they are exposed to the dangers and risks of different jobs of the project.

Tank manufacturing stood second in terms of accident repetition with the amount of 83.6 and repetition range of 11958 person-working hours. A high number of various risky activities in addition to working at height and utilizing hand tools are reasons for the occurrence of the accidents in this unit. The amount of 0.29 for incident severity shows the relatively high accident severity. Incident severity in these parts is 10 times more than incident severity in testing and mapping activities. Workshop is equipping stood third in terms of accident repetition with the amount of 82.3.

The range of accident repetition was 12140 person-hours. This activity consists of all sub-activities needed for workshop equipping with facilities, structures, and constructions. Piping activities with accidental repetition amount of 74.9 were in the 4th position. The range of accident repetition was 13341 person-hours, and incident severity was the highest with the amount of 0.40. Hence, paying special attention to this part might influentially impact on the decline of the accidents. It is worth mentioning that, there were no ethical limitations throughout the whole course of this research.

CONCLUSION

Considering the incident severity and incident frequency, factors such as age, job background, accident reasons, technical safety training courses, regular inspection of sub-activities, creating a suitable and safe occupational environment, applying control measures, considering safety and HSE provisions in the contracts, making employers to employ professional safety personnel, paying statements based on the percentage of HSE regulations, and certain constant supervision might decrease the number of accidents.

Ethical Issues

In this study, the Islamic Azad University ethics committee approved the study protocol and researches explained all procedures and requirements to participants. They voluntarily signed a consent form before enrolling in the study.

Conflict of Interest

There are no conflicts of interest.

Authors' Contributions

All authors equally help to write this manuscript.

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