A NEW HAZARD EVALUATION PROCEDURE FOR PREDICTING RISK FACTORS OF OCCUPATIONAL ACCIDENTS

Hüseyin CEYLAN[1]

ABTRACT

With annual average of 73,937 occupational accidents and 1,152 deaths, Turkey still faces an important problem. The country exercises one of the lowest performances in job safety among the European Union countries. Developments in technology increased the importance of safety management in industry. These improvements also resulted in a requirement of more investment and assignment on human in work systems. This situation increases the importance of forecasting the possible accidents that workers can face and preventing the accidents by taking necessary precautions. In this study a prognostic model has been developed to forecast the occupational accidents in coming periods at the departments of the facilities in hazardous work systems. The validity of the proposed model has been proved by implementing it into practice in hazardous work systems in the manufacturing industry.

Keywords: Occupational accidents; Job safety; Hazard evaluation procedure; Ergonomics.

1. Introduction and Aim

While industry is developing rapidly, machines, tools and equipments which are used in working places have both increased in number and become more complex. Unfortunately, in the process of industrialization of human being, there have been dramatic increases in the accidents that occur in working places as a result of negligence [1,2,3,4,5,6,7,8]. These changes bring into question that occupational accident is a problem which should be focused on.

In parallel with technologic development, it has become compulsory to do studies for the issues that cause decrease of performance and danger for establishment for the safety of workers who are productive elements in a working place. As a result of studies, some laws and regulations that include working order and condition are put into action [20]. However, these regulations are found inadequate and the problem is approached from different aspects. In the end the concept 'Job Safety' emerged [4, 12].

To humanize work environment, in other words to make work environment appropriate for people, enables both an increase in workers' performance and risk reduction for workers' possible accidents. Job and man, these two elements, are important factors in ergonomic job engineering. Accordingly, for the studies designing safe work environments, to examine the interaction between these two factors carry great importance [4, 12, 13].

Investigation related to the reasons of occupational accidents has been one of the main topics in occupation safety works of ergonomists for many years. The approaches developed in this subject constitute the basis of studies to prevent accidents. Many theories have been developed to clarify the reasons of the accidents [4, 12].

The main objective of this study is to provide a reliable decision support tool to the studies of occupational safety management by determining the threading factors with computer support and providing safe workplaces for workers, especially for manufacturing industries.

[1]Yrd.Doç.Dr., Kırıkkale Üniversitesi, Kırıkkale MYO, husceylan@hotmail.com

2. Occupational Accidents and Their Reasons

2.1. Occupational accident term

The dictionary meaning of “accident” is an unfortunate mishap; especially one causing damage or injury in the dictionary of the Turkish Linguistic Agency [22]. A single definition of occupational accidents is not enough. There are many definitions for occupational accident concept in literature. Some of them are as below:

According to the Ministry of Labor and Social Security, the definition of occupational accident is “The workers loss of his/her all or some work power because of working conditions or machines, tools and equipments”[4].

According to the International Labor Organization’s definition; an accident is a “Previously unplanned and unexpected event causing damage or injury” [4]. According to the World Health Organization; accidents are defined as “Events previously unplanned, often causing personal injury, or damage to machinery or making the production stop for sometime.”

Another definition is that; “An accident is a sudden event causing physical damage to the workers while working, going to work or while taking care of the equipments.” [4, 12].

In addition, the comprehensive legal definition of the occupational accident is also available. According to Turkish Law’s 13th clause of Social Insurance and General Health Insurance Law numbered 5510, a broader definition can be identified. According to this definition, occupational accident is an event that happens in one of the following situations causing the insured physically or mentally damaged at the time of the accident or afterwards.

a) When the insured worker is at the workplace,
b) Due to work being carried out by the employer, the insured was conducting business on his own behalf and for the account of independent running,
c) During the time period when employee is being sent to another place by employer and not doing his/her actual work task at the time of the accident,
d) During breastfeeding of a women employee,
e) During transportation of the employees by an employer provided vehicle [20].

It is noted that the definition is so wide and indirectly related topic is related with the occupational accident term. The most typical example of this situation is the traffic accidents that happen during traveling to work and home that are also accepted as occupational accidents.

As we see from the definitions above, eventhough there are lots of definitions about occupational accident concept, common points can be seen. In order to define an event as an accident, the factors below should happen:

- Happening suddenly
- Happening unintentionally
- Extra ordinary
- Directly or indirectly related with company operations
- Financial or moral loses

The studies on the prevention of occupational accidents need to identify the cause of occupational accidents [1, 2, 3, 4, 9, 10]. However, solution for occupational accidents is possible by identifying source of the problems.

2.2. Reasons for Occupational Accidents

Nowadays, all experts agree that there is not a single reason for the accidents and that accidents occur as a result of many negative factors. Basically it is a fact accepted by everyone that accidents occur as a result of different contributions of different factors causing accidents. The main factors can be listed below:

* Not having protective safety measures in machinery and benches used or not using the ones at present,
* Untrained employee on occupational health and safety at work,
* Workers' not having the appropriate personal protective equipmentor not using the ones provided,
* The employees' not knowing or ignoring the occupational health and safety measures,
* Errors in installation of machinery and benches and design,
* Not controlling the workplace health and working conditions,
* Secondary factors other than the above-mentioned factors.

When we categorize the factors listed above, the main topics can be listed as human-based causes, disorders caused by technical reasons (machinery and equipments) and reasons due to organizational disorders.

3. Technique of Deviation From Weighted Means

This model that give us a significant idea about the causes of work-related accidents occur in production systems, estimates risk factors which pose danger for the future by rationally examining the pre-work accidents that are difficult to be seen [4, 8].

In order to avoid the accidents in the workplaces, the source of danger or hazard should be put to an end. If that is not possible, the source should be completely isolated. By analyzing the case of accidents occurring in their own businesses and taking measures on time and place, possible accidents may be prevented. Therefore, preventing or reducing work-related accidents may be possible primarily by concentrating on insecure environments and determining the causes of accidents in these environments. It may also be possible by a systematic approach that continuously reviews and takes necessary measures. The developed "Technique of deviation from weighted means" provides useful information in this regard.

3.1. The Methodology of Technique of Deviation from Weighted Means

The occupational accidents who, when, where and how will be exposed to is unknown, can be estimated by several statistical methods on the basis of the reports from the past. The algorithm, with this philosophy, by interpreting the past accident data of the enterprise for the years, estimates risk factors posing danger in a complete production system. Measures taken in the light of these estimates are likely to prevent occupational accidents.

3.1.1 Creating Data Base

Apriority:

First, in order to obtain the scope of the application of the system, we need to take into consideration the reliability of the (the reports) information and the statistical reliability of the numbers of the accidents in the past. Then, if the number of the accidents are within the required reliability and the number, the system is reviewed.

Factor Definition:

Every information group related with the accident in the reports defines a 'factor'. 12 different factors have been identified regarding the accident reports. For example, in an accident report, " Workshop" from the "Workshop" factor, "Title" from the "Duty" factors, "the date, time and shift" from the "Shift Hour", "Week-day" and "Month" factors "Place of" is from "Bench" factor can be obtained (Table 3).

Level Definition:

Sub-groups of factors are called "level". Therefore factor in the information sets, defines the levels of these factors. For example, as every month can form a level, the factor of month can be formed in 12 levels (as January, February, March,...., November and December). Similarly, every section in a factory such as Iron Foundry, Quality Control, etc. can form a level of the workshop factor (Table 3).

Numeric Analysis and Computer Code:

Analysis is conducted on the computer according to the desired level of reliability and detail. At this stage, the available information is entered by the computer operators. As well as operators enter the raw data (as written in the report) (in this case, the encoding process is done on the computer later), pre-coding can also be done. In the installation of the data as raw on computer, it shouldn't be forgotten that besides taking time, it also minimizes the error caused from manually coding.

In addition, for the data in which the mathematical conversion is impossible, data coding can be used. For example, each title in the accident report (Supervisor=1, Melter=2, Electrician=3, Garcon=17, Shaper=18) can be encoded as a level of Duty factor.

Updating Database with weighting coefficients

The weakness of hazard evaluation techniques, that produce quantitative outcomes, results from taking into consideration only statistical data and disregarding the current trend of accidents. Because a factor can be an element in causing accidents but recently, it is not an accident factor. Similarly, a factor which does not cause accidents in past years can give away to accidents today. If all the accident statistics of past are evaluated equally and it is not given much importance to current data, it can be reached to false results because of the reasons stated above.

In this research, for the solution of this important issue weighting accident statistics is come forward. If accident data is weight currently in the statistical studies, the changes, made today, will be able to be realised accordingly. Applied hazard evaluation procedure's activeness will increase.

In this situation, the most important problem to be focused on is with which means accident data is weighted. There is not any definite rule for that, but logically the recent years' data is requred to be multiplied by highest coefficient, while data belonging to first year is multiplied by lowest one. It is obvious that it is necessary to lessen the weighting coefficients from top to the end. Our having accident data of past years is an another parameter which affects the weighting coefficients. If statistics include longer terms in relation to past years' data is multiplied by higher coefficients. If it includes shorter terms last years' data is multiplied by lower means. If weighting coefficients chosen for last years is higher than it is requred to be, activeness of accident data of past years diminishes, problems emerges in the perception of accident trend.

3.1.2 Data Processing

Logic:

Today, it is an accepted fact by everyone that the cause of accidents is not single. Many factors have effects in various ratios on the formation of the accidents. This technique, acting from this point of view, basically, depends on the philosophy of "Accidents happen, by the accident causing contributions of various factors with different ratios". If the accident causes (the first degree reasons on the formation of the accidents and the secondary or lower reasons that indirectly affect) are determined, accidents can be prevented by the measures taken in the light of these reasons. In other words, accidents will be omitted from the system when the factors affecting them are lost. So, these factors should be eliminated starting from the most important ones with their combinations if there are. In this way, the threat of accidents on the system security will be eliminated.

Data analysis:

Data analysis is performed on the data base created in the earlier stages and updated with weighting coefficients. In the analysis, first of all risk factors of system that may cause accident are determined with the use of "averages deviation test".

In the "averages deviation test" separately done for each factor of, first the average number of accidents in one level are calculated. Then, the number of accidents in one level is found in the database. If it focuses on one or more specific levels, this factor is considered as an risk factor. But, if accidents focus on almost all levels (almost close to the average number of accidents, this factor is not considered as a risk factor in an accident.

The risk factors determined in the first step are also ranked in order of importance. Ordering process is done according to the *Frequency ratios*. Frequency ratio, is calculated by dividing the number of accidents focusing on one level by the average number of accidents in one level of the related factor. The factor having the highest frequency ratio is the most important risk factor; the less the frequency ratio is, the less important the risk becomes.

In this technique, the factors affecting the level of detail, is "Coefficient of Deviation" value. This value shows that in order not to take a factor as an risk factor, number of accidents focusing at any level should be many times more than the average number of accidents. For example, if the coefficient of deviation is selected as 2, a factor is determined as the factor of the accident having the number of accidents at any level twice or more than twice the average number of accidents. A smaller amount, even if deviations from the average value, is not considered as a risk factor. If "Coefficient of Deviation"is of a small value, the level of detail increases, if it is big, the level of detail reduces.

Classification of Risks:

Hazard is defined as the potential of an element to give harm to humanbeings, to damage the property and to cause loss of work day or bad effect on reputation. As to risk, it is the possibility of certain and unwanted event to be realised in a certain time. Accordingly, the risk of every hazard is not the same, so in this technique, risks are classified in three groups in relation to their possibility to happen (concentration ratio). These are;

High Risk Hazard Factors	Concentration Ratio >5
Medium Risk Hazard Factors	3,5 < Concentration Ratio < 5
Low Risk Hazard Factors	2 < Concentration Ratio < 3, 5

High Risk Hazard Factors are the risks which should be eliminated and isolated immediately, ***Medium Risk Hazard Factors*** are the risks which should be eliminated and isolated within the bounds of possibility, ***Low Risk Hazard Factors*** are the risks which should be followed meticulously.

4. Application

In order to estimate the accidents on production systems in the future, an application study was conducted in a factory of the manufacturing industry (MKE PİRİNÇSAN INC.) for testing the accuracy of the proposed model within the study. The main reason for choosing this plant is a high rate of occupational and regular reported accidents in the past few years. In application, fourteen year accident data for the years in between1996-2009 (192 accident reports) were processed. The estimates of risk factors for the year 2010 has been completed. Table 1 shows the distribution of this data by years.

Table 1. The annual distribution of the data used in the application of accidents at work.

Year	*Number of occupational accidents*
1996	14
1997	17
1998	11
1999	12
2000	19
2001	15
2002	14
2003	12
2004	11
2005	14
2006	15
2007	11
2008	13
2009	14
2010	21

Before starting to handle tha data, they are needed to be updated with weighting coefficients to be paid attention to the trend of accidents in the last periods. Because in this application there will be estimates for the 2010 by handling the fourteen year data that belong to the years between 1996-2009. The first ten year data involving 1996-2004 were weighted by the coefficient '1', and the data from 2005 to 2009 were respectively weighted by the coefficients '1,2', '1,4', '1,6', '1,8' and '2,0'. That is, the available data for the last year were increased 2 times and, the available data for previous year were increased 1,8 times.

Application study of factors and levels used in Table 2 are derived from accident reports. "Coefficient of Deviation" value used during the application of the study and determining the level of detail was taken as 2. That is a factor, focusing on the number of accidents at any level, 2 or more than twice the average value of this factor to be considered as a risk factor.

'The Risk Map' obtained as a result of the analysis and showing the possible risk factors in 2010 is shown in Figure 1.

Low Risk Hazard Factors	**Medium Risk Hazard Factors**	**High Risk Hazard Factors**
Age 46-50	**Month** July	**Bench** Oven
Body Hand finger	**Duty** Melter	**Bench** Press
Shift-hour 1		**Workshop** Iron Foun.
Workshop Press		**Duty** Presser

Figure 1. Risk map of factory according to technique of deviation from weighted means.

Table 2. The factors and the levels gained by accident reports.

Factors

Level No	Duty 1	Age 2	Experience 3	Workshop 4	Bench 5	Action type 6	Body 7	Week-day 8	Shift 9	Shift Hour 10	Month-Day 11	Month 12
1	Supervisor	.. – 20	.. – 5	Fitter's Shop	Anode	Dust run	Head	Monday	7:30/15:30	0 – 1	1 – 10	January
2	Melter	21 – 25	6 – 10	Mould Shop	Pipe	Falling	Eye	Tuesday	15:30/23:30	1 – 2	11 – 20	February
3	Electrician	26 – 30	11 – 15	Iron Foundry	Pulling	Obj. Cutting	Arm	Wednesday	23:30 / 7:30	2 – 3	21 – 31	March
4	Presser	31 – 35	16 – 20	Pressing	Decoupage	Obj. Falling	Hand&Finge	Thursday		3 – 4		April
5	Rolling miller	36 – 40	21 – 25	Milling Hall	Rectification	Jamming Obj. in.	Waist	Friday		4 – 5		May
6	Wire Puller	41 – 45	26–30	Thimble	Milling Cutter	Obj. Crash	Leg			5 – 6		June
7	Cutter	46 – 50	30–...	Electrolyze	Frohling	Firing	Foot &Finger			6 – 7		July
8	Maintainer	51 – 55		Repair-Mainte.	Milling	Load lift. inj.	Body			7 – 8		August
9	Unloading	56 – ..		Construction	Work Car	Spraining						September
10	Laboratorian			Electrical Shop	Cratos							October
11	Welder			Wire cable	Scissors							November
12	Assistant			Steam Pow.Pl.	Driller							December
13	Turner			TAM	Kitchen							
14	Mechanist			Quality Contr	Oven							
15	Electronics			Dissolution	Package							
16	Designer			Social Found.	Press							
17	Garcon				Switch							
18	Shaper				Strip							
19	Driver				Furnace							
20					Jigsaw							
21					Football field							
22					Turner							
23					Crane							
24					Cup Press							

5. Results of Application

5.1 Investigation of Factors on the Basis Accidents Occurred in 2010 (Actual Status)

In 2010, 21 accidents occurred in the factory where the application was done. The data of this accidents is shown in Table 3. Here, this table will be examined separately for each factor. Factors are influential in the formation of accidents, which affect the occurrence of accidents that will be investigated.

Duty Factor: The duty factor has 18 levels (Table 2). Depending on the 21 accidents happened in 2010 in the factory, (21/18 ≈ 1,16) 1 accident happened in each factor on average. However, in 2010 Pressers made 7, Melter 5, Maintainer 3, Electrician 2 and 1 Rolling Miller, Shaper, Driver and Unloading. In other words, accidents mainly happened by Presser, Melter, Maintainer and no other accidents were reported in the remaining 10 levels (Table 3). Duty factor is, therefore, an effective factor in the occurrence of the accidents and should be included in the risk map according to the predictions made for 2010. When Figure 1 is analyzed, both Pressers and Melter level of the duty factor can be seen as a risk factor in the Risk Map.

Age Factor: Age factor has 9 levels (Table 2). The number of accidents in each levels is about (21 / 9≈) 2,33 on average. When Table 3 is examined, from 21 accidents happened in the factory, 17 of them were happened in three levels, no accidents happened in the remaining 4 levels. Then, age factor is a cause of accident and should take palce in the risk estimates for 2010. As it is seen in Figure 1 Age factor is as low risk hazard factor in the risk map.

Experience Factor: Experience factor has 7 levels (Table 2). The number of accidents in each levels is about (21 / 7≈) 3 on average. According to Table 3 accidents are seen to have distributed more or less same in each seven levels. Experience Factor is, therefore, not an accident cause. Depending on the estimates for 2010, this factor was not determined as a risk factor in Risk Map (Figure 1).

Workshop Factor: Workshop factor has 16 levels (Table 2). The number of accidents in each levels is about (21/16≈) 1,31 on average. When Table 3 is analyzed, while there was a significant increase in Iron Foundry and Pressing, no accidents happened in the remaining 10 levels. Then, workshop factor is a cause of accidents. When Figure 1 is examined, both Iron Foundry and Pressing levels of Workshop factor, can be seen as a risk factor in Risk Map.

Bench Factor: Bench factor has 24 levels (Table 2). The average number of accidents for each levels (21/24≈0.875) is less than 1. When Table 3 is examined, from 21 accidents happened in the factory, 13 of them were happened in two benches. Then, bench factor is a cause of accident. Seen in Figure 1, both Oven and Press levels of Bench factor, can be seen as a risk factor in Risk Map.

Action Type Factor: This factor has 9 levels (Table 2). The number of accidents in each levels is about (21/9 ≈) 2,33 on average. Accidents happened in 2010 distributed more or less same in each nine levels (Table 3). Action type factor is, therefore, not an accident cause. Depending on the estimates for 2010, this factor was not determined as a risk factor (Figure 1).

Body Factor: Body factor has 8 levels (Table 2). The average number of accidents for each levels (21 / 8 ≈ 2,63) is less than 3. When Table 3 is examined, from 21 accidents happened in the factory, 13 of them were happened in two levels, no accidents took place in the remaining 3 levels. Then, body factor is a cause of accident. Depending on the estimates for 2010, Hand-Finger level of Body factor was determined as a low risk hazard factor (Figure 1).

Week-Day Factor: This factor has 5 levels (Table 2). The number of accidents in each levels is (21 / 5) 4,2 on average. Accidents happened in 2010 distributed more or less same in each levels (Table 3). Week-Day factor, therefore is not an accident cause. Depending on the estimates for 2010, this factor was not determined as a risk factor (Figure 1).

Shift Factor: Shift Factor has 3 levels. The number of accidents in each levels is (21 / 3) 7 on average. When Table 3 is examined, 8 accidents took place in the first Shift, 4 accident in the second

Shift, and 9 accidents in the third Shift. Although in the third level, there is a concentration, concentration ratio is less than 2 (9/7 1,28). Because in this study the deviation coefficient is taken as 2, this factor is not an accident factor. Depending on the estimates for 2010, this factor was not determined as a risk factor (Figure 1).

Shift-Hour Factor: This factor has 8-levels (Table 2). The number of accidents in each levels is about (21/8 ≈) 2.63 on average. According to Table 3, accidents reported were distributed more or less same in each eight levels. Shift-Hour Factor, therefore is not an accident cause. Depending on the estimates for 2010, this factor was not determined as a risk factor (Figure 1).

Month-Day Factor: This factor has 3-levels (Table 2). The number of accidents in each levels is about (21/3 ≈) 7 on average. According to Table 3, accidents reported were distributed more or less same in each 3 levels. Month-Day Factor is, therefore, not an accident cause. Depending on the estimates for 2010, this factor was not determined as a risk factor (Figure 1).

Month Factor: Month factor has 12 levels (Table 2). The number of accidents in each levels is about (21/12≈) 1.75. When accidents of 2010 were analyzed, no accidents took place in 3 levels, an increase can be seen in July level (Table 3). Then Month Factor is a cause of accidents. Depending on the estimates for 2010, July level of Month factor was determined as a low risk hazard factor (Figure 1).

Tablo 3. Accidents happened at factory in 2010 (Real Action)

	Duty	Age	Experience	Workshop	Bench	Action type	Body	Week-day	Shift	Shift Hour	Month-Day	Month
1. Accident	Presser	38	22	Pressing	Press	Jamming Obj. in.	Foot &Finger	Tuesday	1	1	3	January
2. Accident	Presser	48	33	Iron Foundry	Oven	Falling	Foot &Finger	Monday	3	1	1	February
3. Accident	Maintainer	50	35	------	-------	Spraining	Foot &Finger	Wednesday	1	1	1	February
4. Accident	Electrician	43	17	Iron Foundry	------	Obj. Crash	Foot &Finger	Friday	3	1	3	February
5. Accident	Maintainer	50	31	Repair-Mainte.	------	Obj. Falling	Foot &Finger	Monday	1	7	3	March
6. Accident	Presser	49	28	Iron Foundry	Oven	Load lift. inj.	Waist	Thursday	1	4	3	March
7. Accident	Presser	35	13	Pressing	Press	Obj. Crash	Head	Friday	1	3	3	March
8. Accident	Melter	38	17	Iron Foundry	Oven	Firing	Head	Monday	2	6	1	April
9. Accident	Melter	37	13	Iron Foundry	Oven	Firing	Eye	Tuesday	1	3	2	April
10. Accident	Presser	48	26	Thimble	Press	Obj. Falling	Hand&Finge	Monday	2	5	3	April
11. Accident	Electrician	52	24	Dissolution	-----	Obj. Falling.	Hand&Finge	Monday	1	1	3	May
12. Accident	Presser	42	20	Pressing	Press	Falling	Foot &Finger	Monday	2	5	1	May
13. Accident	Unloading	35	17	------	------	-----	-----	Tuesday	1	4	1	May
14. Accident	Melter	42	25	Iron Foundry	Oven	Firing	Hand&Finge	Wednesday	1	6	3	July
15. Accident	Melter	40	23	Iron Foundry	Oven	Firing	Eye	Friday	1	7	2	July
16. Accident	Rolling mill	50	26	Milling Hall	Press	Jamming Obj. in.	Hand&Finge	Thursday	1	7	1	July
17. Accident	Driver	42	26	------	------	Obj. Falling	Head	Wednesday	1	4	1	July
18. Accident	Melter	37	13	Iron Foundry	Oven	Jamming Obj. in.	Hand&Finge	Tuesday	3	2	3	September
19. Accident	Maintainer	51	35	Repair-Mainte.	------	------	-------	Wednesday	1	1	1	October
20. Accident	Presser	48	26	Thimble	Press	Jamming Obj. in.	Hand&Finge	Wednesday	1	5	2	October
21. Accident	Shaper	38	13	-----	------	Obj. Crash	Hand&Finge	Friday	3	8	2	November
Distribution to Levels	Presser =7 Melter =5 Maintain =3 Electricia= Rolling m=1 Shaper =1 Driver=1	0-20 / 0 21-25 / 0 26-30 / 0 31-35 / 2 36-40 / 6 41-45 / 4 46-50 / 7 51-55 / 2 56-60 / 0	0-5 / 0 6-10 / 0 11-15 / 4 16-20 / 4 20-25 / 4 25-30 / 5 30-35 / 4	Iron Foundr = 8 Pressing = 3 Thimble = 2 Repair-Maint.=2 Milling Hall = 1 Dissolution = 1	Oven = 7 Press = 6	Firing = 4 Obj. Falling.= 4 Jamming Obj. in.=4 Obj. Crash = 3 Falling = 2 Load lift. inj. = 1 Spraining =1	Hand&Fin=7 Foot&Fing=6 Head = 3 Eye = 2 Waist = 1	Monday = 6 Tuesday = 4 Wednesda =5 Thursday =2 Friday = 4	1 / 14 2 / 3 3 / 4	1 / 6 2 / 1 3 / 2 4 / 3 5 / 3 6 / 2 7 / 3 8 / 1	1 / 8 2 / 4 3 / 9	January = 1 Februar = 3 March = 3 April = 3 May = 3 June = - July =4 August = - Septemb=1

	Unloadin= 1											October= 2 Novemb=1 Decembe=-
	♿	♿	☺	♿	♿	☺	♿	☺	☺	♿	☺	♿

♿ = There are focusing on some levels (Should be found as a risk factor).

☺ = The accidents are dispersed to all levels in an almost equal way (not risk factor).

5.2. Comparison of Accident Forecasts to Actual Results

192 accidents were investigated within 14 years of practice between 1996 and 2009. The reasons for the accidents of 2010 were estimated. By examination of Table 3 it is noted that:

***Bench** Factor* at the ***Oven** level* 8 times of the average,
***Bench** Factor* at the ***Press** level* 6.85 times of the average,
***Workshop** Factor* at the ***Iron Foundry** level* 6.09 times of the average,
***Duty** Factor* at the ***Presser** level* 6 times of the average,
***Duty** Factor* at the ***Melter** level* 4.28 times of the average,
***Age** Factor* at the ***46-50** level* 3 times of the average,
***Body** Factor* at the ***Hand-Finger** level* 2.66 times of the average,
***Duty** Factor* at the ***Maintainer** level* 2.57 times of the average,
***Age** Factor* at the ***36-40** level* 2.57 times of the average,
***Workshop** Factor* at the ***Pressing** level* 2.28 times of the average,
***Month** Factor* at the ***July** level* 2.28 times of the average
***Shift Hour** Factor* at the ***1** level* 2.28 times of average,
***Body** Factor* at the ***Foot-Finger** level* 2.28 times of the average,

appears to be the main concentration. According to the results of the proposed technique (deviation from the weighted means) obtained for 2010, "Risk Map" (Figure 1) is concentrated on the following items in the order of significance;

*Of **Bench** Factor, **Oven***
*Of **Bench** Factor, **Press***
*Of **Workshop** Factor, **Iron Foundry***
*Of **Duty** Factor, **Presser***

were determined as High Risk Hazard Factors;

*Of **Duty** Factor, **Melter***

was determined as Medium Risk Hazard Factor;

*Of **Age** Factor*, ***46-50***
*Of **Body** Factor*, ***Hand-Finger***
*Of **Shift Hour** Factor*, ***1***
*Of **Workshop** Factor, **Pressing***
*Of **Month** Factor, **July***

were determined as Low Risk Hazard Factors in the Risk Map.

*Of **Duty** Factor, **Maintainer***
*Of **Age** Factor*, ***36-40***
*Of **Body** Factor*, ***Foot-Finger***

were not determined as a risk factor in the Risk Map obtained from the proposed technique. Based on the results of 2010, 10 out of 13 of the most important risk factors were determined by the technique. 3 factors, that were not determined as the risk as a result of practice.

6. Discussion of Results and Recommendations

To prevent or reduce the industrial accidents; the main reasons that cause the accident must be determined by researchers and analyzers. The system must be healed, the correctional measures must be taken and finally it must be controlled regularly if the measures are implemented or not. The problem that is generally seen in Turkey is that, the correctional measures that are determined to prevent the accidents are not implemented with the same sensibility. Consequently, the main concern in workplace safety is to check up the correctional measures regularly and to check if the measures are implemented correctly. The success in preventing the industrial accidents depends on this process.

In this study a quantitative risk assessment technique is developed. In comparison with the existing threat assessment techniques, proposed technique could be underlined in the following six aspects:

* The developed technique is the basic starting point of an official document called "Accident Report". This technique is based on neither on the experts opinion nor the assumptions; its' major initiative is in the accident reports.

* Produces quantitative results.

* In this technique, the latest trends of accidents can be detected as all available statistical data is not scrutinized in the same category, also the latest data is weighted. This important quality removes the possibility that all present quantitative hazard evaluation techniques have.

* Another major feature of the technique is that it is simple, easy to understand and inexpensive. The only statistical knowledge that is needed by the staff who will utilize this application is the calculation of the average data value. Any kind of spreadsheet is sufficient for creating database for this program. In addition, staff who will utilize this application does not need to have an expert level of knowledge about the systems of the specific workplace.

* This technique could be effectively applied medium and large-scale factories. It is not suitable to apply in small-scale factories, since there are not enough accurate accident reports, nor enough statistical data.

*Technique is able to detect errors caused by both machine and staff. In application of this technique, since all available factory accident data are evaluated, a complete system-related malfunctions and defects could easily be detected. In comparison to the techniques on the basis of accidents or workshops, proposed technique is more time-efficient. The time required for the application of this technique to a medium or large-scale enterprise is maximum one week.

**** Since the proposed t***echnique is a quantitative method, historical statistical data is required for proper evaluation. For this reason, this technique is applicable to operational phase and not for the designing or planning stages of a project.

**** The major requirement for the validity of the proposed technique is recording the accidents reports in a proper manner***. Fake or missing accident reports are the major weaknesses of this technique.

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