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Occupational Accident Analysis in Oil & Gas Drilling Sector Turkey and in Relevant Industry in General

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Abstract:- Occupational accidents during oil and gas drilling operations in Turkey were investigated in this study where the aim of this study is to compare Turkey with the global industry and to outline the current situation in Turkey in terms of occupational accidents taking place throughout drilling operations. In order to provide a perspective regarding the situation in Turkey, a comparison was based on International Association of Drilling Contractors (IADC) data was made. Occupational accidents between 2011 and 2017 were investigated and compared using a Univariate Descriptive Frequency Analysis utilizing data of 5,943 occupational accidents of the organization and 703 data of occupational accidents from various other companies/organizations in Turkey. Using Discriminant Analysis and Principal Component Analysis, the study tries to assess the actual situation regarding occupational accidents in Turkey. The study concludes that Turkey is considerably above world average regarding occupational accidents in drilling operations and that the situation in Turkey is going worse indicating that Turkey should promptly take serious measures to reduce the number of such incidents occurring in the industry.

Keywords:- *Discriminant Analysis, Principal Component Analysis, Oil and Gas Drilling, Occupational Health and Safety, Occupational Accidents*

I. INTRODUCTION

There are 32,897 employees officially registered as per the social security records (within the scope of article 4/1-a of Law No. 5510) working in the field of oil and gas drilling activities between 2011 and 2017 in Turkey. A total of 1,682 occupational accidents were reported in this field and 8 of these resulted in deaths. Standardized rates were calculated for 2011-2017 for the sectors where most of the occupational accidents occurred in Turkey. According to this calculation, the mining support services industry, including drilling operations, is among the sectors with the highest number of occupational accidents.

To access healthy and precise data on occupational accidents is not possible due to the fact that incident reporting is considered as a loss of prestige for companies. Therefore, studies conducted in the field of occupational accidents are based on data which do not depict the whole picture. In order to prevent companies from not reporting incidents, it is mandatory by law to keep and report the relevant data of occupational accidents and diseases. However, institutions willing to make comparisons using the statistics on accidents cannot use these statistics since the records kept by the state are provided in a general format. Hence, different institutions are established for keeping statistics on occupational accidents one of which is The International Association of Drilling Contractors (IADC) established in the U.S.A. In this study, the IADC data are used in order to assess the status of Turkey among other countries in terms of occupational accidents occurring in the drilling industry and make comparisons among the countries.

There are various studies conducted on occupational accidents which took place during drilling operations. Kuyucu (2016) investigated Geothermal Drilling operations in Turkey in terms of Occupational Health and Safety. Çakar, C. (2009), provided a risk assessment generated by an analysis technique on type of incident and its impact on drilling site/facility. In that study, the occupational hazards and risk assessment on the deepest and most extensive borehole drilled by Turkish Petroleum Corporation (TPAO) in Turkey are provided. It is found that the riskiest works are those where hand tools are used and electricity is involved. Köse, N. (2016), states that the environmental and occupational health and safety management system applications in the case of TPAO will reduce the number of accidents. In the study by O'Dea, A., & Flin, R. (2001), made specifically on offshore oil and gas drilling operations, it is stated that the occupational accidents could be reduced if the field managers play a role as occupational safety leaders. The study investigating occupational safety culture in the drilling fields revealed that occupational safety in the drilling industry is still insufficient despite all the developments and there is still need for studies to be made to ensure improvement. Graham, J., Irving, J., Tang, X., Sellers, S., Crisp, J., Horwitz, D., ... & Carey, D. (2015) found that the number of the traffic accidents occurred in drilling fields increased in time. Chan, M. (2011) stated that excessive fatigue is an effective factor in oil and gas drilling accidents. The study stated that combating fatigue and stress management are necessary in order to reduce the

accidents. Fabiano, B., & Currò, F. (2012) conducted a survey to measure occupational safety culture for a 9-year period on a firm working in the oil industry. According to the results of the survey, the administrators' leadership on the site and establishment of a corporate safety culture are critical. Occupational accidents in oil and gas drilling operations can result in great disasters by the nature of the activity. According to the BP Deepwater Horizon Accident and Response Report (2011), it was the largest oil platform accident in the world occurred in the history where 11 workers lost their lives and 17 workers were heavily injured in 2010. After this accident, approximately 5 million cubic meters of crude oil seeped into the ocean and the company had to spend over 20 billion USD for rehabilitation activities. This accident proved that any minor mistake neglected during drilling could cause irreparable damage and fatalities as well as destructive effects on environment with additional outcomes like financial damage and loss of prestige for companies, which are very hard to compensate.

According to European Oil Refinery Industry safety report published by Concawe in 2005, it is stated that the occupational accidents are lower compared to the previous years and to other sectors in terms of their frequency. However, it is stated that more than 50% of fatal occupational accidents are related to traffic and transportation accidents in this industry. According to the 2008 data of U.S. Department of Labor (https://www.bls.gov/iif/oshwc/osh/os/osar0013.htm); a total of 120 fatal occupational accidents occurred in the oil and gas drilling industry. The top three most fatal incidents were transportation accidents (41 %), contact with objects and equipment (25 %), and fire and explosions (15%). Three quarters of the transport incidents were related to traffic/road accidents. It was reported that four fatal occupational accidents had been reported where a pedestrian was hit by a vehicle or mobile equipment in 2008 and five people were injured in 2008 due to an aircraft occupational accident. The report also shows that fatal injuries had occurred in 22 of the 30 incidents due to the contact with objects and equipment.

II. MATERIALS AND METHODS

➢ *Statistics on Occupational Accidents*

The occupational accident analyses in the oil and gas drilling industry were made primarily in line with the data provided by Social Security Institution (SSI) Annual Statistical Reports and comparison was made with the data of International Association of Drilling Contractors (IADC) in order to assess the situation of Turkey on the basis of occupational accidents. Subsequently, one of the largest companies operating in Turkey was taken as a case example; statistics on occupational accidents between 2011 and 2017 were obtained.

In order to reduce occupational accidents, researches on occupational health and safety are continuously implemented on a global scale aiming to identify the causes of accidents. Thus, occupational accident statistics should be used to achieve the purpose of these studies. Accuracy of occupational accident statistics is vital to identify the source of the incidents. Different formulae were produced to determine the frequency of occupational accidents. For assessing the status of countries relative to each other and standardizing the analyses, use the occupational accident rate formulae which were defined in 1998 during the 16th International Labor Statistics Conference (ILO, 2010) was decided. Accordingly, each of the formulae published consists of a numerator and a denominator and the frequency of occupational accidents employed in most these formulae, is calculated by multiplying 1,000,000 with the ratio of number of cases occurring at the time referenced to the total working hours worked by the employee referenced. According to the regulation published by the European Parliament, member countries are obliged to keep statistics of occupational accidents and submit them annually. In accordance with 89/391/EEC Framework Directive adopted by Turkey keeping the records of occupational incidents that resulted in at least 3 days of lost time is a requirement. SSI collects and logs these records of occupational accidents reported by workplaces/companies. The statistics are published and sent to Eurostat in accordance with these European Union (EU) directives. SSI uses the formulae defined by the European Statistics on Accidents at Work (ESAW) when providing its annual occupational accident statistics. Two types of statistical calculations are used as Occupational Accident Frequency Rate and Occupational Accident Severity Rate.

Two methods are used to calculate the Occupational Accident Frequency Rate (SSI Annual Statistic Reports, 2011-2017).

$$Incidence\ Rate = \frac{Number\ of\ Incidence}{Total\ number\ of\ worked\ days \times 8} \times 1{,}000{,}000$$

$$Incidence\ Rate = \frac{Number\ of\ Incidence}{Total\ number\ of\ worked\ days \times 8} \times 225{,}000$$

Another criterion used in the assessment of occupational accidents is the Standardized Occupational Accident Rate (SR) and is calculated as follows.

$$SR\ (\%) = \frac{Number\ employment\ injuries\ (ei)\ in\ the\ branch\ of\ activities\ in\ the\ year\ \times\ 100}{Expected\ number\ of\ employment\ injury}$$

$$Expected\ number\ of\ ei = General\ ei\ speed \times Number\ of\ insured\ in\ the\ branch\ of\ activities$$

$$General\ ei\ speed = \frac{Total\ number\ of\ ei}{Total\ number\ of\ insured}$$

In this study, the standardized occupational accident rates between 2011 and 2017 are calculated on a sectoral basis and the situation of oil and gas drilling operations compared to other sectors is provided.

Comparison between Turkey and other countries in terms of occupational accidents are made in line with the accident analysis published in International IADC Incident Statistics Program [http://www.iadc.org/isp/].

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Data of IADC member countries and Turkey Incident Rate calculation formulae are used for the comparison with associated examples below:

$$Recordable\ Frequency\ Rate = \frac{Number\ of\ Total\ Incidence}{Total\ ManHour} \times 1{,}000{,}000$$

$$Recordable\ Incidence\ Rate = \frac{Number\ of\ Total\ Incidence}{Total\ ManHour} \times 200{,}000$$

$$ManHour = Number\ of\ Employees \times \text{Daily Work Hours} \times \text{Average Work Days}$$

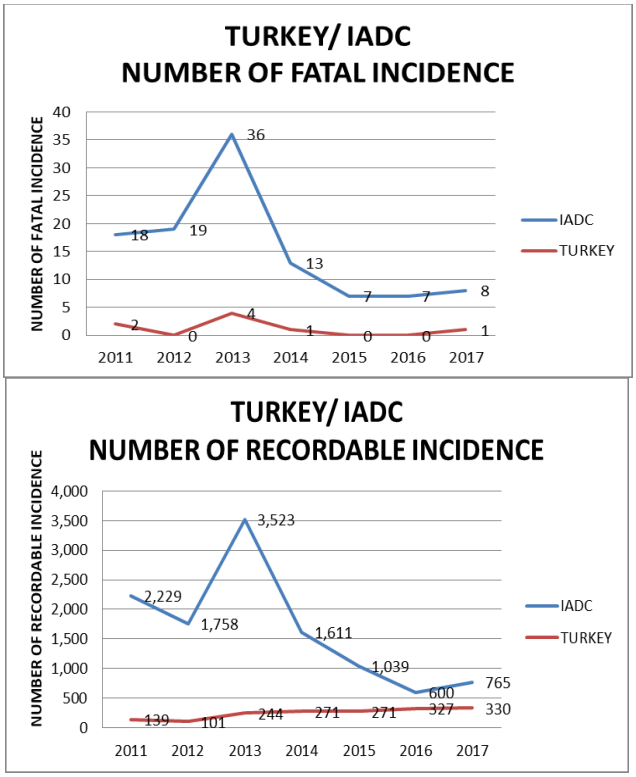
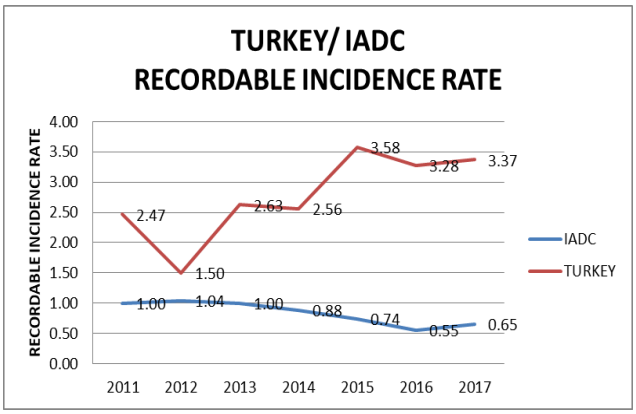


Fig 1:- The Comparison between Turkey / IADC Worldwide Number of Occupational Accidents (IADC Total Industry Land Drilling Accident Data, taken from Occupational Accident Statistics Program Annual Reports between 2011 and 2017 http://www.iadc.org/isp/. Data of Turkey is taken from SSI Annual Occupational Accident Statistics.)



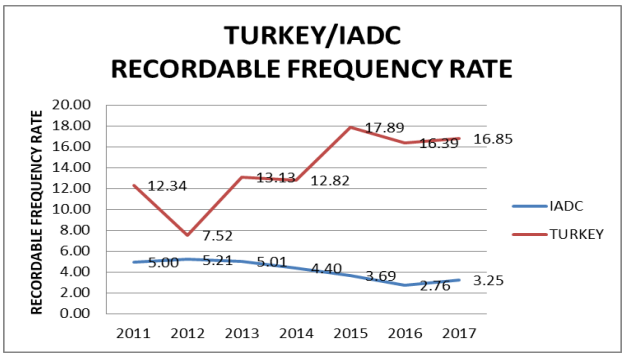


Fig 2:- The Comparison between Turkey / IADC Worldwide Recordable (Rcrd.) Incidence Rate and Rcrd. Frequency Rate (IADC Total Industry Land Drilling Incidence Rate data, taken from Occupational Accident Statistics Program Annual Reports between 2011 and 2017 http://www.iadc.org/isp/ . Data of Turkey is taken from SSI Annual Occupational Accident Statistics.)

Figure 1 and 2 reveal that current situation of Turkey is significantly higher than the IADC average regarding occupational accidents in the oil and gas drilling industry.

- *Analysis of Occupational Accidents in the Oil and Gas Drilling Industry of Turkey*

Comparisons between SSI general occupational accidents and occupational accidents in the oil and gas drilling industry are calculated based on the data published in SSI annual statistics. From 2011 to 2017, the comparison between frequency of occupational accidents across Turkey and frequency of occupational accidents in the oil and gas drilling industry is shown in Figure 3.

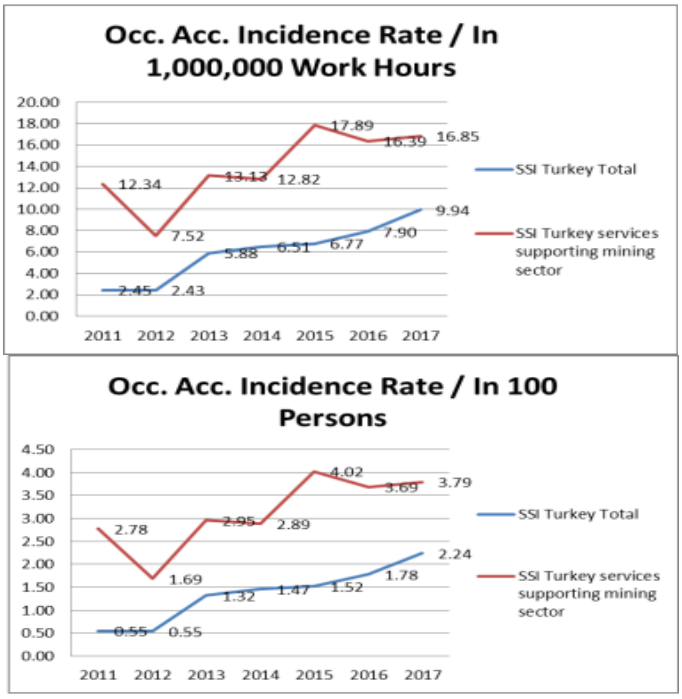


Fig 3:- The comparison between occupational accidents in drilling industry of Turkey (services supporting mining industry) and SSI General occupational accident (Occ. Acc.) frequency rate (Data are calculated based on SSI annual statistics.)

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Accordingly; the number of occupational accidents in the oil and gas drilling industry in Turkey is significantly above the general average of IADC occupational accidents. At the same time, it is observed that the numbers of occupational accidents tend to increase according to the distribution over the years.

Standardized Occupational Accident Rates are used to investigate the occupational accidents in terms of the field of activity. When the Total Standardized Occupational Accident Rates are considered, it is observed that the highest occupational accident rate is in the mining industry, followed by the metal industry, air transport, services supporting the mining sector and construction respectively (Figure 4).

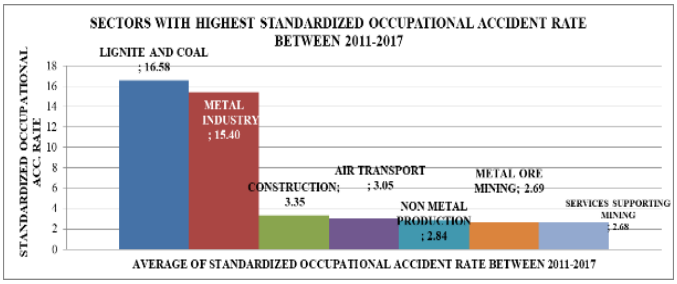

Fig 4:- Sectors with the Highest Standardized Occupational Accident Rate between 2011 and 2017

➢ *IADC vs. Turkey Comparison: Univariate Descriptive Frequency Analysis*

The variables used in occupational accident statistics are important for examining the distribution and frequency rate of each variable to detect the reasons causing the accident and prevent new accidents. Univariate Descriptive Frequency Analysis is one of the most fundamental statistical analysis methods and shows the distribution between the categories of each variable (Babbie, 2010). The most important purpose of the analysis is to provide an understanding of the database and it is the basis for multivariate analysis. Researchers primarily prefer to use this analysis method in occupational accident analyses (Kazan, 2013). MS Excel is used for providing the univariate descriptive frequency analysis in this study; frequency analysis of each data category was conducted and frequency distributions were examined. The results of these analyses were later provided in the form of graphs for interpretation.

Frequency analysis was conducted in line with the occupational accidents between 2011 and 2017, between IADC members and Turkey. A comparison between lost time incidents and total recordable occupational incidents was also incorporated. The analyses were performed to assess the situation of private sector in Turkey and are made in line respectively with the following variables; season(s) when the accidents occurred, occupation(s) of the worker, location of the injury on the body, cause of injury (type of accident), equipment used, specific activity carried out by the worker during accident, place where the accident occurred, experience of worker in the project, time when accident occurred and age of worker.

➢ *Discriminant Analysis (DA)*

Discriminant Analysis is the process of revealing the differences of two or more groups by discriminant variables. It is a broad concept covering several closely related statistical approaches (Klecka 1980). Discriminant functions obtained through DA consist of linear components of predicted variables. Discriminant functions reveal which predicted variables affect the differences between groups. These variable affecting the differences between groups are called as discriminant variables. Another function of DA is to determine the group of a unit, origin group of which is not known although it belongs to any of the groups, with least error. DA also helps to determine where the difference is concentrated mostly on which variables and thus to determine the factors causing to differentiation in the groups. With the classification enabled through this analysis, it is possible to compare the original group members, which in turn enables testing whether the known function is sufficient or not (Erçetin 1993).

DA model comprises linear combination of independent variables and is given as in the following formula (Çakmak, 1989):

$$f_{km} = v_1 X_{1km} + v_2 X_{2km} + v_3 X_{3km} + \ldots\ldots\ldots\ldots + v_p X_{pkm}$$

f_{km}: the value of the discriminant function for the m^{th} observation in the k^{th} group
X_{ikm}: the value of the i^{th} variable for the m^{th} individual (observation) in the k^{th} group
v_i : coefficients of the function

While structuring the function, the ratio of inter-group variance to intra-group variance should be maximum (Malthora, 1996).

$$(F = \max(\frac{inter-group\ variance}{intra-group\ variance})$$

The v_i coefficient in the function defined above in general form is calculated through the equation $(W\text{-}1B - \lambda I)\ V = 0$ for a latent value of "λ" (which is) different than "0" found as a solution to the equation $|W^{-1}B - \lambda I| = 0$. W stands for the sum of intra-group squares and cross product matrix while B represents the sum of inter-group squares and cross product matrix (Çakmak,1989).

➢ *Principal Component Analysis (PCA)*

Principal Components Analysis, studied in 1901 by Karl Pearson, was developed by Hotelling in 1933 (Filiz, 2003). PCA is a transformation technique which reduces the size of a data set containing a large number of interrelated variables while preserving the changes in the data as much as possible (Çilli, 2007). PCA aims to determine the best transformation that can express the data at hand with fewer variables. The analysis basically follows the sequence below:

- a data matrix of p variables in n calculations is standardized,
- a correlation matrix for the standardized data matrix is constructed,
- latent values and standardized eigen vectors of (a) correlation vector are calculated,
- explained ratio of principal components are computed through the latent values,
- principal component values are calculated through recasting the data matrix standardized with the transpose of each eigen vector.

Under circumstances where small number of the principal components explain more than 80% of total variance, it is stated that these components then can replace the original p variable without a major loss of information.

III. RESULTS AND DISCUSSION

➢ *Frequency Analysis (Turkey/IADC Comparison)*

Total Recordable Accident Analysis was made on 9,570 accidents for IADC incidents, while it was made on 453 accidents for Turkey. Frequency Analysis findings of total recordable accidents are given below. Findings provided belong to those accidents observed mostly in comparison to the others.

Based on season-wise consideration, it is observed that accidents mostly occurred in summer (27.11%), however in Turkey occurrence is mostly in autumn by 28.48% (refer to Annex-I, Graph-1).

Accidents according to professions are given in Annex-I, Graph-2; floorman (42.50%), derrickman (13.94%), Motorman/Mechanic (Repair Technician)/Maintenance Supervisor (11.80%) are the personnel who were exposed such incidents mostly. The percentages in Turkey are as follows; floorman (59.22%), derrickman (8.25%) and Motorman/Mechanic (Repair Technician)/Maintenance Supervisor (8.98%).

The most commonly injured body parts in the industry in general as given in Annex-I, Graph-3 are fingers (30.80%), head (12.25%), hand/wrist (10.26%) and feet (9.54%). In Turkey, these are fingers (26.25%), head (11.93%), hand/wrist (10.63%) and feet (6.51%).

Distribution by accident types in industry in general are due to; caught between/in (31.03%), struck by (28.01%), slip/fall: different level (8.55%), slip/fall same level (7.74%), strain/overexertion (5.98%). The case for Turkey, occurred due to; struck by (26.49%), caught between/in (20.75%), traffic (11.92%), slip/fall: different level (7.73%) (refer to Annex-I, Graph-4).

Occupational accidents caused by the equipment used; pipes/collars/tubulars/casing (13.11%), hand tools: manual (8.85%), tongs (6.23%), engines/pumps/machinery (4.70%). Different from the foregone accidents occurred mostly in Turkey due to; pipes/collars/tubulars/casing (15. 01%), vehicles/transportation (12.58%), hand tools: manual (10.82%), engines/pumps/machinery (10.38%), material (7.06%) (refer to Annex-I, Graph-5).

Ranking of accidents by activity in the industry in general is as follows: rigging up/down (18.16%), tripping in/ out (15.30%), rig/equipment repair or maintenance (11.44%), routine drilling operation (10.22%). Rankings of accidents by activity in Turkey are as follows; rig/equipment repair or maintenance (23.62%), routine drilling operation (18.32%), travel/transportation (12.58%), walking (7.06%) (refer to Annex-I, Graph-6).

According to the place where accidents occurred, the average of the percentages in industry in general are; rig floor (35.33%), rig pad/rig decks (rig/well site/location) (10.18%), cellar/substructure/moonpool (6.69%) respectively. The same for Turkey; derrick/mast (30.75%), rig floor (18.58%), truck/car/bus (13.05%), mud mixing tank/area (4.20%), winch truck / forklift/ crane (4.20%) (refer to Annex-I, Graph-7).

Accident analysis according to 1-5 years of experience level of the workers in the industry in general is 38.52% and 50.77% in Turkey (refer to Annex-I, Graph-8).

Occupational accidents occurred between more or less in the same hours both in Turkey (51.66%) and in the industry in general (44.69%). Most of such accidents occurred between 09:00 A.M. and 04:00 P.M. (Annex-I, Graph-9).

Age-wise distribution among workers between 26-35 years old those were victims of occupational accidents in general (46.97%) and in Turkey (51.90%) are similar (refer to Annex-I, Graph-10).

➢ *Principal Component Analysis (PCA)*

Principal Component Analysis was used to illustrate the situation in Turkey regarding occupational accidents and to show how Turkey and other countries improved in terms of accidents between the years 2011-2017. Data regarding the variables for Turkey are obtained from SSI, whereas other data are compiled from IADC's website. PCA uses five variables with explanations provided for their abbreviations below.

TOTAL MANHOURS: Total Man-Hour
TOTAL FTLs: Total Number of Fatal Incidents
TOTAL RCRD: Total Recordable Occupational Accidents
RCRD INCD. RATE: Total Recordables Rate
RCRD FREQ. RATE: Total Recordables Frequency Rate

The Bartlett's Test of Sphericity was used to determine whether the data set was appropriate for the analysis of principal components. According to the test results given below (Sig. = 0.000 <0.05), it shows that the data set is appropriate for the analysis of principal components (PC). These variables were entered into the Minitab software and PCA was performed accordingly. Factor groups were formed by the PCA method and the number of variables was reduced.

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Method	Test Statistic	P-Value
Multiple comparisons	—	0,000
Levene	7,55	0,000

Following the above, PCA was performed using the data set. As can be seen below, after performing the PCA, it was found that the two components explained 97.1% of the total data set cumulatively.

Eigenanalysis of the Correlation Matrix

Eigenvalue	2,7983	2,0581	0,1071	0,0365	-0,0000
Proportion	0,560	0,412	0,021	0,007	-0,000
Cumulative	0,560	0,971	0,993	1,000	1,000

Variable	PC1	PC2
TOTAL MANHOURS	0,551	-0,195
TOTAL FTLs	0,587	-0,032
TOTAL RCRD	0,585	0,056
RCRD INCD. RATE	0,068	0,692
RCRD FREQ. RATE	0,068	0,692

The values circled indicate the contribution of each component to the cumulative variance, respectively. That is, by using the first 2 or 3 components rather than using 5 components, explainability is ensured (0.97 or 0.99). Hence purpose of PCA, that is dimension(al) reduction is achieved.

The first component from the coefficients of the variables (TOTAL MANHOURS, TOTAL FTLs, TOTAL RCRD) represents these variables mainly. The second component represents the variables of RCRD INCD. RATE, RCRD FREQ. RATE.

The graph in Figure 5 shows a change in the scale of accidents between 2011 and 2017. It is observed that Canada and America improved in terms of occupational accidents within 6 years. However, the situation got worse in terms of accidents in Turkey in those 6 years. The first component shows the number of accidents and the change on the x-axis does not change significantly for Turkey. However, when the second component on the y-axis showing the accident rates is observed, it can be seen that the situation in Turkey is not going well, since the rate of the accidents is increased.

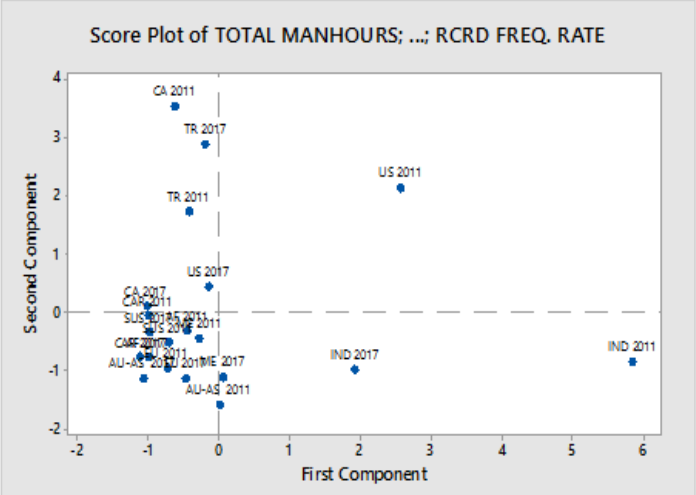

Fig 5:- Principal Component Analysis Results, Comparison between Turkey and other countries worldwide. Abbreviations: United States (USA), Canada (CA), Central America and Caribbean (CAR), Europe (EU), Africa (AFR), Middle East (ME), Asia and Australia (AU-AS), South America (SUS), Industry in Total (IND), Turkey (TR).

➢ *Discriminant Analysis (DA)*

Discriminant Analysis was made using sample values of a selected Turkish company where a total of reported 453 accidents (occurred) between 2011 and 2017 were taken into consideration for the analysis. In the study, only the accidents which occurred in the oil and gas drilling industry were selected; near miss incidents were not included in the data set since data of the workers was not (made) available. DA was conducted covering 317 cases (including incidents due to traffic, lost time incidents and the ones where first aid was required).

DA is carried out on continuous variables among the determined variables. Categorical variables are used by using frequency analysis in comparison with other countries in the world. In the DA, predominantly the predicted variables are determined to be age, year of accident, reporting period, experience, pump power, hook load, rig value, number of employees per shift, total number of employees, salary and amount of money lost. According to the DA results, the clusters could be determined with an accuracy of 78.2%. Accidents were divided into clusters as the ones requiring first aid with an accuracy of 89.1%, accidents with lost work days with an accuracy of 63.3% and traffic accidents with an accuracy of 55.9%. That is, 248 out of a total of 317 data could be clustered correctly.

Vehicle accidents that could not be classified in sufficient levels were excluded from the DA and only accidents with lost work days and those requiring first aid were included in the classification. Since traffic accidents are not related to the drilling activity during the drilling operation, removal from the classification did not lead to any deviations in calculations. Failure to obtain results from the discriminant analysis of traffic accidents is due to the fact that the predicted data for drilling accidents cannot be added to this type of accidents and at the same time some of the traffic accidents do not cause any injury; some required first aid and some caused lost work days only. A separate examination of these accidents in particular would be beneficial.

DA was performed with the same predictors previously determined. According to the results of DA applied, the clusters could be determined with an accuracy of 88.7%. According to the results of this analysis, the clusters can be classified as accidents requiring first aid with accuracy of 99.5% and accidents with lost work days with 65.6% accuracy. In other words, 251 out of the total 283 data could be clustered correctly.

IV. CONCLUSION

Various occupational incidents and fatalities can occur during oil and gas drilling operations, which are among the most hazardous field of activities alongside with mining, even though occupational health and safety regulations are strictly applied. In cases where such regulations are not taken seriously into account, results can be devastating. Intensity of drilling operations in Turkey are increasing to explore and exploit oil and similar resources in order to cover the energy deficit. This study is the first with this extent in its field outlining and assessing the current situation of the drilling industry in Turkey. Among the findings obtained in the study, the following are especially noteworthy:

- It is observed that the U.S. and Canada displayed a considerable achievement in terms of 1st and 2nd components as per the PSA graph between 2011 and 2017. The first components (the x-axis) in terms of number of accidents has improved throughout the industry however the second component on the y-axis that is the incident rate/frequency rate does not depict that much of an improvement. The case in Turkey is almost the opposite with an increase in the number of accidents from 2011 to 2017. Increase in accident reporting could be an effect to this increase nonetheless it is evident that it is absolutely at an anomalous status when compared to other countries.
- Accidents are grouped based on the type of occurrence and a Discrimination Analysis is made for detailed investigation. Accidents of similar type are considered as one single group and the analysis is made on 3 main groups. This will enable effective reporting and record keeping hence resulting in data availability for further analyses.
- According to the analysis of accidents in Turkey based on SSI, statistics indicate that there is an increasing trend in the number of accidents in this industry. Increase in the number of accidents indicates that sufficient and satisfactory preventive measures are not taken. In order to achieve world average ranking in occupational accidents in Turkey, utilization of machinery and equipment manufactured with recent technology standards would be beneficial.
- Moreover, when the situation of Turkey examined in comparison to other countries in the world in line with IADC data, it is observed that the rate of total recordables in Turkey is 3.37, where the average of the industry in general is 0.65. Thus, the rate of Turkey is approximately 418% higher in comparison to the rate of industry average. While the recordable accident frequency rate is taken into consideration, the industry average is 3.25 whereas the rate of Turkey is 16.85. Accordingly, the frequency rate in Turkey still seems to be far above the industry average.
- According to the results of Principal Component Analysis, a significant improvement and development is achieved in other countries in terms of accident rates, whereas the occupational accidents have considerably increased from 2011 to 2017 in Turkey.
- It is considered that this study would be a useful guide and an initial attempt for conducting analyses of this kind towards the oil and gas drilling industry in Turkey and contributes to; more accurate reporting of incidents, motivating employees and improved studies to enhance awareness and helps companies in taking more effective measures.

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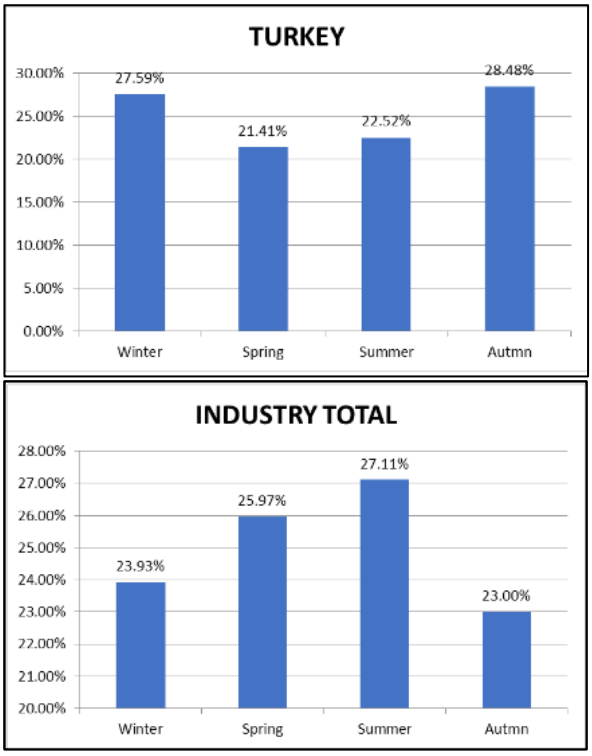
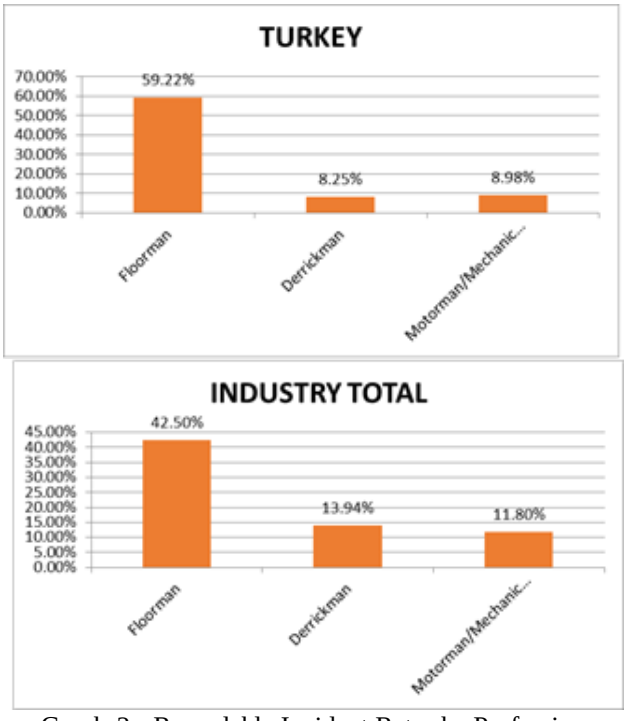
ANNEX-I TOTAL RECORDABLE INCIDENT ANALYSIS (IADC / TURKEY)

In order to provide clear understanding of the tables below, the tables are organized in consideration of the data with the highest ratio in tables comprising huge amount of data. Since it is not possible to include the whole data set on simplified graphs below, the sum of data does not add-up to 100%.



Graph-1:- Recordable Incident Rates by Season



Graph-2:- Recordable Incident Rates by Profession

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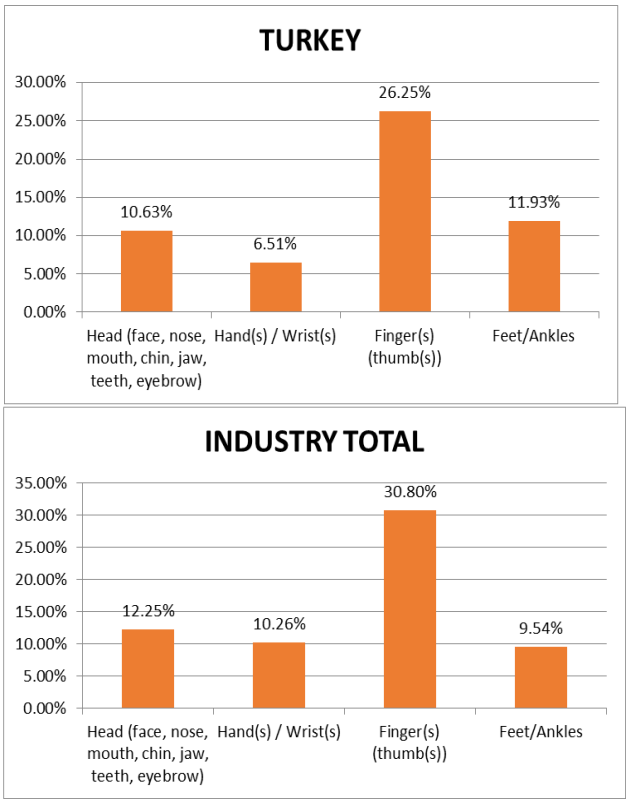
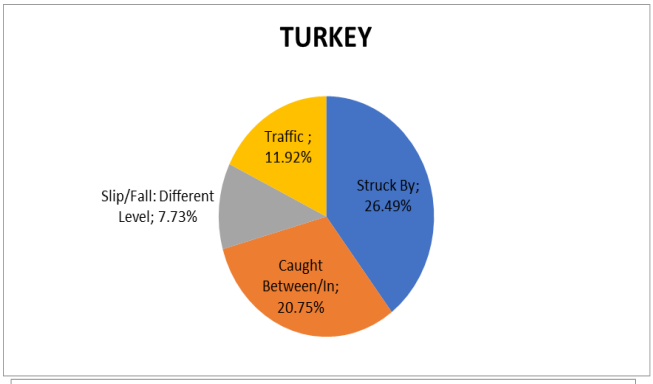
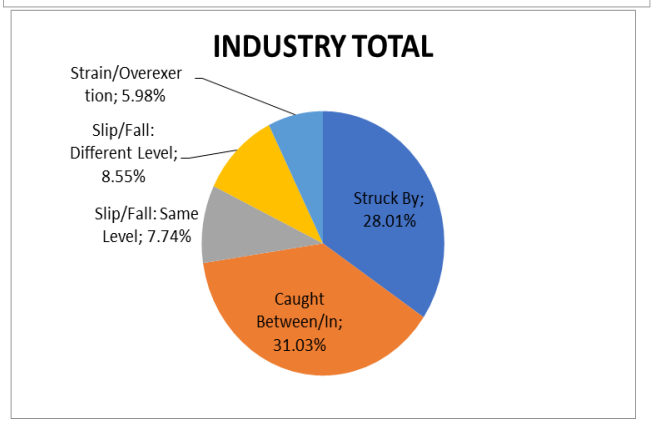
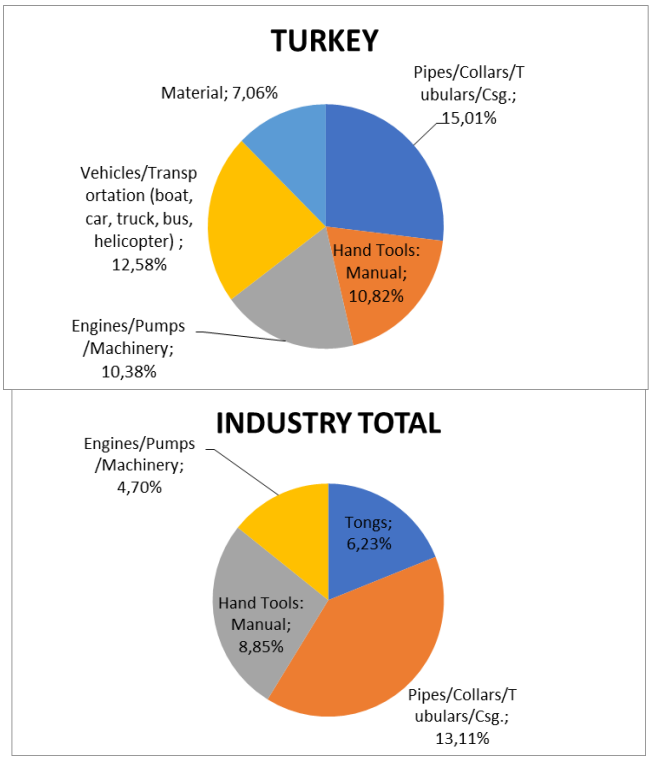


Graph-3:- Recordable Incident Rates by Injured Body Parts

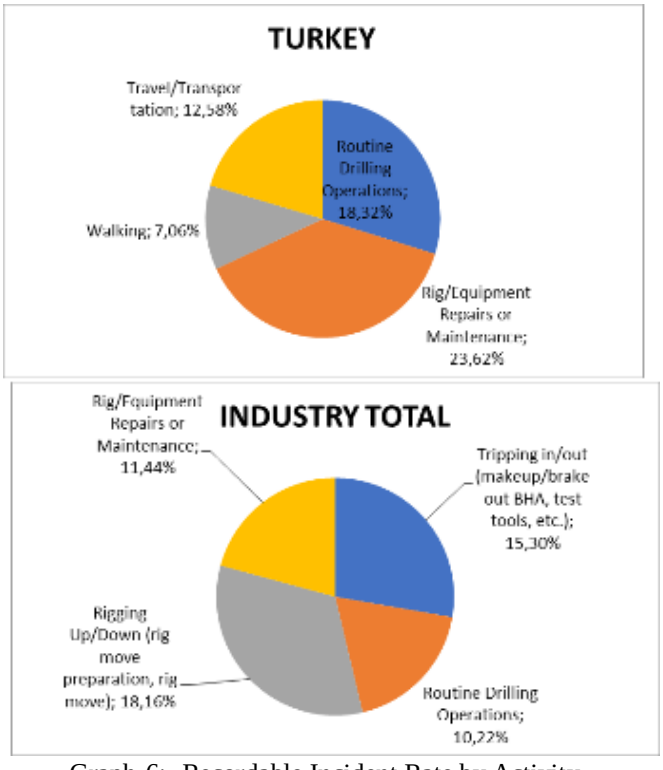




Graph-4:- Recordable Incident Rates by Accident Type



Graph-5:- Recordable Incident Rate by Machine / Equipment



Graph-6:- Recordable Incident Rate by Activity

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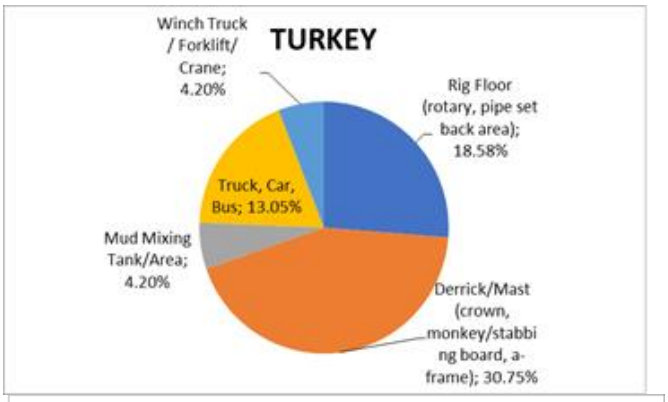
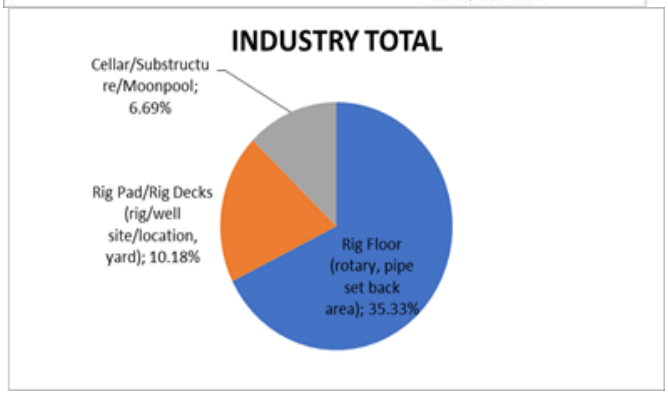
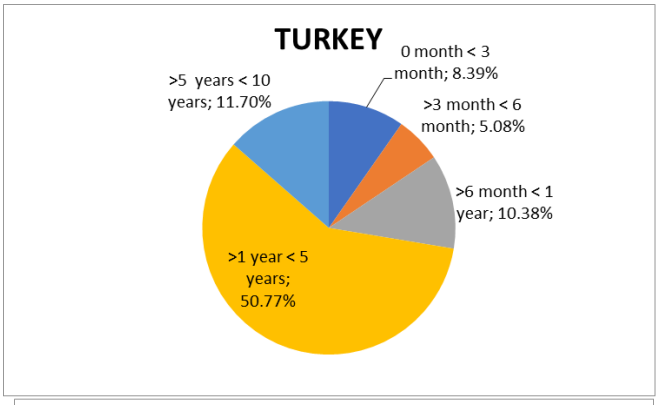
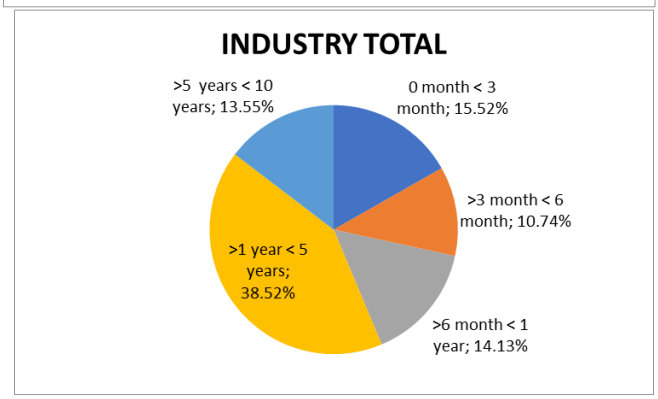


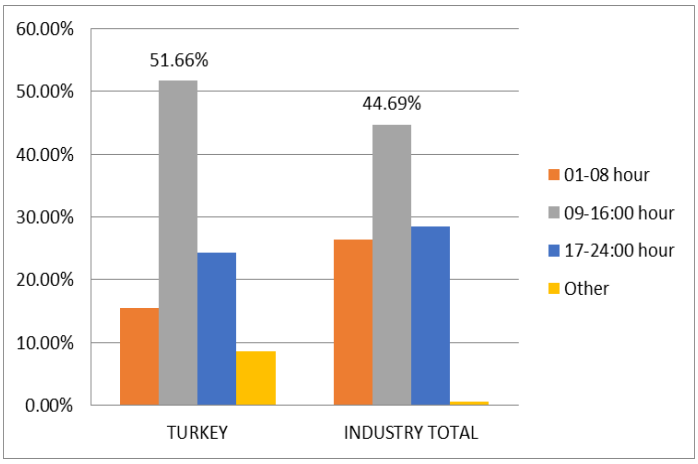


Graph-7:- Recordable Incident Rate by Place Where the Accident Occurred

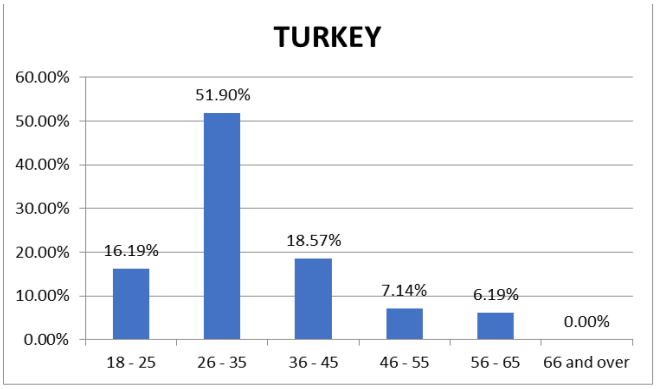


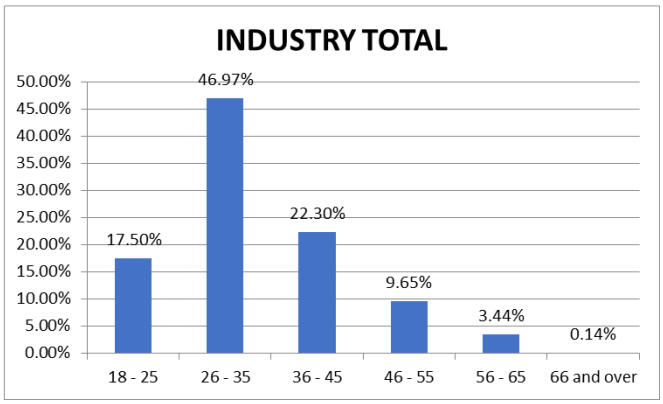


Graph-8:- Recordable Incident Rates by Experience



Graph-9:- Recordable Incident Rates by Time





Graph-10:- Recordable Incident Rates by Age