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Safety Climate Analysis at Power Station

A thesis submitted in partial fulfillment of the requirements for the
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ABSTRACT

Safety is one of the main important issues for all workers in the industrial sector. Safety contains many subjects/concepts such as safety culture and safety climate. Those two concepts are considered as one of the main concern across the industrial sector today. For both concepts still there is no universal definition but we can find many corresponding definitions for these concepts. As simple definition is that the safety culture is “*Making sure people are not harmed is how we do things here*”. The safety climate can be defined as “*Safety climate is a summary concept describing the safety ethic in an organization or workplace which is reflected in employees’ beliefs about safety*”.

The present work evaluate the safety climate as it is a reflection of the safety culture and it is considered as a fast tool to evaluate safety culture with minimum resources required. The evaluation is done for two private power companies, which is Al Ezzel power plant. As well as another Al Dur power and water production plant. Both plants are located in Bahrain and under the management of Al Ezzel Operation and Maintenance (O&M) Company. The evaluation was done through questionnaires including all the staff (around 200). The questionnaire is designed based on literature review and previous questionnaires. In order to validate and support the questionnaire, interviews werw conducted. Analysis has been done by different statistical methods using Microsoft excel software.

The results of safety climate evaluation showed that the level of safety for Al Ezzel O&M is above average (3.67 of 5). In addition, the safety level for Al Ezzel site (3.93) is higher than Al Dur site (3.49). By studying the safety level for different departments, four groups were identified, which are: 1) Al Ezzel daytime workers, 2) Al Ezzel shift workers, 3) Al Dur daytime workers, and 4) Al Dur shift workers. The level of safety for daytime workers was higher than shift workers. Also, the study reveal some factors that affect the safety climate level, such as, the nature of the work, the experience and the number of attended safety workshops.

Recommendations are provided such as communicating safety culture definition and reevaluating safety culture periodically.

DEDICATION

This work is dedicated to my parents who raised me up, and to my wife who supported me in all my steps.

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I would like to acknowledge the guidance of Prof. Ahmed Youssef, the Thesis Supervisor, during all phases of this research.

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B	Safety Climate Questionnaire
C	Interview questions
D	Mean score calculation
E	Questionnaire of improvement suggestions
F	Formulas used in Microsoft Excel for analysis

ABBREVIATIONS

CANSO	Civil Air Navigation Services Organization
GCC	Gulf Cooperation Council
GDF	Gas De France
HSE	Health, Safety and Environment
ICC	Interclass correlation coefficient
INSAG	International Nuclear Safety Advisory Group
MGD	Million Gallons per day
NOSACQ	Nordic Safety Climate Questionnaire
NS	Non-Significant
O&M	Operation and Maintenance
RO	Reverse Osmosis

Chapter one

Introduction

1.1 Overview

1.2 Research background

1.3 Problem statement and research justification

1.4 Research aim and objectives

1.5 Thesis structure

Chapter one

Introduction

1. Introduction

This chapter provides an overview of the thesis, explaining the research background and the objectives of this thesis. Also the justification of this thesis is stated and finally the structure of the thesis is briefly introduced.

1.1. Overview

Part of human nature is the need for safety, so the issue of safety is a human concern by nature. In the industrial sector, where significant hazards may occur; the need for safety requires the utmost attention. It is important to feel safe while working and to have a safety system in place, which has reflective indicators in order to improve it. It is a crucial matter to everyone.

In recent years there has been movement away from safety measures based on retrospective data which called ‘lagging indicators’ such as fatalities and time lost in accidents, towards what is called ‘leading indicators’ such as safety audits or measurements of safety climate. The leading indicators can enhance the process of finding weakness without risking the failure of the system (Flin, Mearns, O'Connor & Bryden, 2000).

“Industries worldwide are showing increased interest in concept of safety culture as means of reducing the potential for large-scale disasters, as well as the inherent risks associated with routine tasks.” (Cooper, 2002) (p. 1)

So studying the safety culture can be an efficient method to detect the weaknesses in the safety system in order to prevent any occurrence of unsafe events in the future. In the present study, the safety climate will be analyzed as a reflection of the safety culture, since it's an important leading indicator.

1.2. Research background

Identifying the level of safety culture is difficult and takes a long time, so more common is to evaluate the safety climate which is considered as a reflection or a snap shot of the safety culture. Therefore the safety climate can be considered as an alternative safety indicator, (The Civil Air Navigation Services Organization [CANSO], 2008; Guldenmund, 2010). Guldenmund (2010) said “*Organizational culture expresses itself through organizational climate*” (p. 18) Schein (2010) said “*Climate will be a reflection and manifestation of cultural assumption*” (p. 230)

The studies of safety culture and safety climate started since 1980. The studies include different fields such industry, construction, energy, aviation, health care and services (Guldenmund, 2010). That mean the idea of studying the safety culture can be applied to the power plants.

1.3. Problem statement and research justification

Among the companies of Gas DeFrance-Suez (GDF-Suez) (The mother company for the studied power plant) the fatal accidents keep happening from time to time, even with applying high standard of safety (GDF-Suez records, 2013). So the headquarter has recently assigned the task of safety improvement as an objective to all the companies in the region because this problem can lead and raise social, legal and economic issues to the company and effect its image worldwide. A presentation has been conducted in 2014

about fatal accidents in GDF-Suez during 5 years, after a discussion about the safety culture and how it affects the safety levels; it was chosen to target the safety climate as a way to study the safety level in the company.

The targeted company didn't have any lost time accident from commissioning till now which is a great safety achievement, and it got in 2013 the first position in safety among all other companies in our region but it still records near misses, (Al-Ezzel documents, 2014). Any near miss can lead to accident, which may involve life losses, (Heinrich, 1980). Although there is no accident it is essential to be proactive and evaluate the safety climate for improvement to overcome any future accident. For example, NASA in 1986 was known for using high standards of safety but in that year the space shuttle Challenger exploded while launching, which means that there was a hidden problem with the safety, and it needs to be evaluated, (Vaughan, D, 1996; Guldenmund, 2010).

1.4. Research aim and objectives

The main aim of the present study is to improve the safety culture of the company; the following are the description of the thesis objectives:

- 1- To evaluate the safety climate level at Al Ezzel O&M.
- 2- To find out the factors affecting the safety level.
- 3- To detect sub-climate existence between departments.
- 4- To find out the weaknesses in the safety system.
- 5- To recommend improvements for the existing safety level.
- 6- To derive new definition for safety culture based on employees understanding.

1.5. Thesis structure

This master thesis is composed of seven chapters. This the first chapter which is the introduction to the thesis. The remaining chapters as follow:

Chapter 2 contains summary about the studied company which is Al Ezzel Operation and Maintenance (Al Ezzel O&M) and its two power plants Al Ezzel power plant and Al Dur Power and Water production plant, with a brief about the mother company which is called Gas de France-Suez (GDF-Suez).

Chapter 3 includes the theory background of the organizational culture, safety culture and safety climate, with explanation of the relation between them. It also explains the importance of measuring the safety climate and the way of measuring it using a questionnaire and interviews. The previous studies also reviewed as part of this chapter.

Chapter 4 explains the way of implementing the safety climate measuring tools (questionnaire and interviews) with validity and reliability. The used techniques to analyze the results of the measuring procedure are included. Chapter 5 presents the results of the questionnaire and interviews through graphs (histograms and radar charts) and tables, with the analysis of the results.

Chapter 6 discusses methods used in this master thesis, the results of analyzing the questionnaire and the interviews, and how it compared to the results of previous researches.

Chapter 7 summarizes overall findings, followed by recommendations for the company and the future research.

Chapter two

Company Description

2.1 Al Ezzel power plant

2.2 Al Dur power and water production plant

2.3 Company current safety situation

Chapter two

Company Description

2. Company Description

AL Ezzel O&M is part of GDF-Suez group which includes companies across 30 countries around the world for power production (gas, diesel, coal, solar, wind, hydropower), water production, oil refinery and gas production. The total capacity of power around the world for GDF-Suez is 76.9GW in 2013, (GDF-Suez, 2013).

In the gulf the total available power for GDF-Suez companies is 27GW of electricity and 5.3 million m³/day of distillate water divided between 23 plants which include gas turbines, steam turbines, distillers and reverse osmosis units, (GDF-Suez, 2013).

GDF-Suez own two companies in Bahrain, Hidd Power Company and AL Ezzel O&M Company. Al Ezzel O&M own two plants, Al Ezzel power plant and Al Dur power and water production plan, (GDF-Suez, 2013). The total production of Al Hidd and Al Ezzel O&M provide 79% and 70% of power and water of daily demand in Bahrain , respectively (MEW, 2015a, 2015b). Hidd power plant is producing power in combined cycle mode by 5 gas turbines and 2 steam turbines with capacity of 1030MW, and it produce distillate water by 10 distillers with maximum capacity of 90.39 million empirical gallons/day, (HPC, 2015). AL Ezzel O&M own two plants, Al Ezzel power plant and Al Dur power and water production plant, offering

56% of Bahrain needs of electricity and 21% of daily needs of water, (MEW, 2015a, 2015b).

2.1. Al Ezzel power plant

This plant produces 950MW of electricity. It consists of two blocks; each block has two gas turbines and one steam turbine. The gas turbine can run in simple mode or combined cycle mode to supply the required heat to the steam generation. All gas turbine fired by natural gas as a fuel. The company started to operation in 2006 with gas turbines only and in 2007, the steam turbines came in service, (Al-Ezzel documents, and 2006).

2.2. Al Dur power and water production plant

This plant produces 1227 MW of electricity. It consists of two blocks; each block has two gas turbines and one steam turbine. The gas turbine can run in simple mode or combined cycle mode to supply the required heat to the steam generation. All gas turbine fired by natural gas as primary fuel or diesel as emergency fuel. The maximum production capacity of distillate water is 48 million gallon/day (MGD). The desalination technique is reverse osmosis (RO). It has started operation in 2012, (Al-Ezzel documents, 2013).

2.3. Company current safety situation

GDF-Suez joined “International Power Company” at 2013, after this joining, GDF-Suez started to implement higher standards of safety rules and permit to work system in all its subsidiary companies, the process of implementation is still in progress, (Al-Ezzel documents, 2014).

Al Ezzel safety department is responsible about ensuring the proper implementation of the safety rules. The safety rules include applying high

standard of permit to work system that provided by the mother company. In addition, it includes an annual internal safety audit on other departments. Moreover, the department ensures that the proper training is provided such as firefighting, evacuation procedure and safe using of portable equipment. Training courses include online and practical courses. Furthermore the company has strict system to check all the equipment periodically from safe provision and it should be approved by the general manager.

All the indicators of AL Ezzel O&M are showing high level of safety, such as: no “Lost Time Accidents” for 3500 day in Al Ezzel plant and 2000 day in Al Dur plant, getting first rank in HSE among GDF-Suez companies across our region in 2013 and getting OHSAS 18001:2007 certificate – refer to appendix A for more information about OHSAS 18001:2007, (AL Ezzel documents, 2014). Although, the company indicators are showing positive signs, it stills recording near-misses. The company safety records are showing that the near-misses rate is almost constant during the past four years, which are four to five near-misses per year. 65% of near-misses occur in Al Dur site and 35% occur in Al Ezzel site, (Al-Ezzel documents, 2015). This number of near-misses can raise the probability of death occurrence. That gives a sign for a dangerous situation within the company, and means the existence of hidden issues within the safety system of the company. The hidden issues can be discovered by using a leading indicator such as the safety climate, (Guldenmund, 2010).

Chapter three

Literature Review

- 3.1 Organizational culture
- 3.2 Safety culture
- 3.3 The components of safety culture
- 3.4 Safety climate
- 3.5 The relationship between safety culture and safety climate
- 3.6 Benefits of a good safety culture and safety climate
- 3.7 Methods for evaluating safety culture
- 3.8 Using questionnaire and interviews to evaluate safety climate
- 3.9 Questionnaire as a method
- 3.10 Interviews as a method
- 3.11 Directions of safety climate studies
- 3.12 Safety climate: fields of study
- 3.13 Focus of current study
- 3.14 Summary

Chapter three

Literature Review

3. Literature Review

The literature review will be about the concepts of organizational culture, safety culture and safety climate. In addition, the relation between safety culture and safety climate will be mentioned alongside with the tools used to evaluate the safety climate.

3.1. Organizational culture

The safety culture is sub-fact of organizational culture (Cooper, 2000), and this concept has its origin in the concept of organizational culture, (Norden-Hagg, 2010). The concept of organizational culture and climate gained much attention in 1970's and 1980's, (Guldenmund, 2010). Through decades of research, such concept of organizational culture has not been agreed on with a specific definition, but many researchers stated that the organizational culture is a way of describing the organization, (Reason, 1997; Norden-Hagg, 2010).

Guldenmund (2010) summarized the characteristics of organizational culture based on researches and studies of former scientists (Guion, 1973; James, 1982; De Cock et al., 1986; Schein, 2010) as following: *“Overall, organizational culture is relatively stable, multidimensional, holistic construct shared by (group of) organizational members that supplies a frame of reference and which gives meaning to and/or is typically revealed*

in certain practices” (p. 21). Tompkins (2005) reach similar conclusion to the organizational culture characteristics.

As mentioned earlier, still there is no standard agreed definition for organizational culture, here are some definitions presented below for the concept:

- 1- Cooper (2000) “*Organizational culture is a concept often used to describe shared corporate values that effect and influence and members’ attitudes and behaviors*” (p. 111)
- 2- Schein (2010) “*...a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as correct way to perceive, think and feel in relation to those problems*” (p. 18)
- 3- Reason (1997) “*Shared values (what is important) and beliefs (how things work) that interact with an organization’s structure and control systems to produce behavioral norms (the way we do things around here)*” (p. 192)

3.2. Safety culture

As organizational culture concept, safety culture concept also does not have a specific standard definition. For first time, the term of safety culture was introduced by the International Nuclear Safety Advisory group (INSAG) in 1986 after the Chernobyl accident in their first report (INSAG-1, 1986). The definition was revised later and expanded in (INSAG-12) (1999) as following: “*The phrase ‘safety culture’ refers to a very general matter, the*

personal dedication and accountability of all individuals engaged in any activity which has a bearing on the safety of nuclear power plants.” (p. 12)

The definition of safety culture is not based on the organizational culture and with the lack of theoretical background, which lead to generate a lot of definitions for safety culture, resulted in non-agreed relation between safety culture and organizational culture, (Guldenmund, 2010; Choudhry, Fang & Mohamed, 2007, Cooper, 2000).

Table 3.1 gives list of collected definitions for the safety culture.

Table (3.1) Examples of safety culture definitions and their original references.

Original reference	Definition of safety culture
Cox & Cox (1991)	<i>“Safety cultures reflect the attitudes, beliefs, perceptions, and values that employees share in relation to safety”</i>
International Nuclear Safety Advisory Group (1991)	<i>“Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance”</i>
Pidgeon (1991)	<i>“The set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious”</i>
Ostrom, Wilhelmsen & Kaplan (1993)	<i>“The concept that the organization’s beliefs and attitudes, manifested in actions, policies, and procedures, affects its safety performance”</i>
Geller (1994)	<i>“In a total safety culture (TSC), everyone feels responsible for safety and pursues it on a daily basis”</i>
Berends (1996)	<i>“The collective mental programming towards safety of a group of organization members”</i>
Lee (1996)	<i>“The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, and organization’s health and safety management (ACSNi)”</i>
Kennedy and Kirwan (1998)	<i>“An abstract concept, which is underpinned by the amalgamation of individual and group perceptions, thought processes, feelings and behaviors, which in turn gives rise to the particular way of doing things in the organization. It is a sub-element of the overall organizational culture”</i>

Hale (2000)	<i>“the attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems”</i>
Glendon and Stanton (2000)	<i>“Comprises attitudes, behaviors, norms and values, personal responsibilities as well as human resources features such as training and development”</i>
Cooper (2000)	<i>“Culture is „the product of multiple goal-directed interactions between people (psychological), jobs (behavioral) and the organization (situational); while safety culture is „that observable degree of effort by which all organizational members directs their attention and actions toward improving safety on a daily basis””</i>
Mohamed (2003)	<i>“A sub-facet of organizational culture, which affects workers” attitudes and behavior in relation to an organization’s on-going safety performance”</i>
Richter and Koch (2004)	<i>“Shared and learned meanings, experiences and interpretations of work and safety - expressed partially symbolically – which guide people’s actions towards risk, accidents and prevention”</i>
Fang et al. (2006)	<i>“A set of prevailing indicators, beliefs and values that the organization owns in safety”</i>
Guldenmund (2010)	<i>“...those aspects of the organizational culture which will impact on attitudes and behavior related to increasing or decreasing risk.”</i>

Many definitions introduced are based on the type of organization that is involved in the study, for example the definition of (INSAG) is based on nuclear plants. Other definition stated in a study performed by the civil air navigation services organization (CANSO) (2008) is related directly to the safe provision of air navigation. CANSO proposed their definition in 2008 as follows:

“Safety culture refers to the enduring value, priority and commitment placed on safety by every individual and every group at every level of the organization. Safety culture reflects the individual, group and organizational attitudes, norms and behaviors related to the safe provision of air navigation services.”

(p. 1)

Mathis and Galloway (2013) did not provide their own definition but they put the guidelines of the definition and the elements that should be available to construct the definition and they leave the definition to be understood as anyone wants.

3.3. The components of safety culture

The safety culture model was proposed by many researchers with few differences, but the most used model, was introduced by Cooper (2000).

Cooper (2000) constructed a model of safety culture based on Bandura's (1977, 1986) model of reciprocal determinism. This model consists of three interrelation aspects. Cooper (2000) said: "*Bandura's reciprocal model appears to offer the perfect framework with which to analyze organizational (safety) 'culture'*" (p. 119). The three aspects of model of reciprocal determinism are person, situation and behavior. This model is shown in figure 3.1

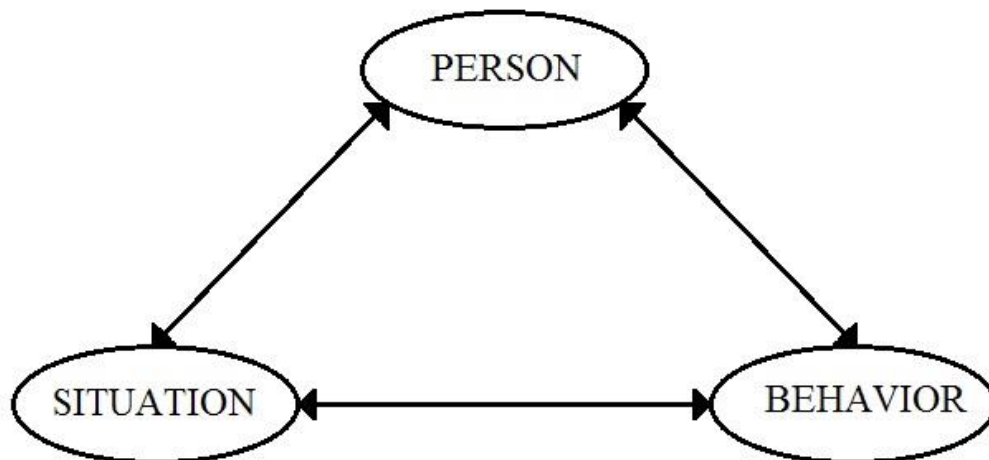


Figure (3.1) Bandura's (1977, 1986) model of reciprocal determinism.

Cooper (2000) adopted Bandura's model (1977, 1986) as a structure for the safety culture model. He also described the safety culture based on the work of Reason (1997) and Guldenmund (2000). Cooper model was used later by many studies like (CANSO, 2008) and (Jin & Chen, 2013). Cooper model is re-detailed later by Cooper and Finley (2013).

Cooper model consists of three interrelated aspects of safety culture, the psychological aspects, behavioral aspects and the situational aspects. The psychological aspects refer to the safety climate by other words, "How people feel" about safety and safety management system. The behavioral aspect is the safety behavior, which means "What people do" with regard to safety issues and the management commitment to safety. The situational aspects refer to safety management system, such as procedures, policies, regulations and communication system, (Cooper, 2000). Safety culture model is shown in figure 3.2.

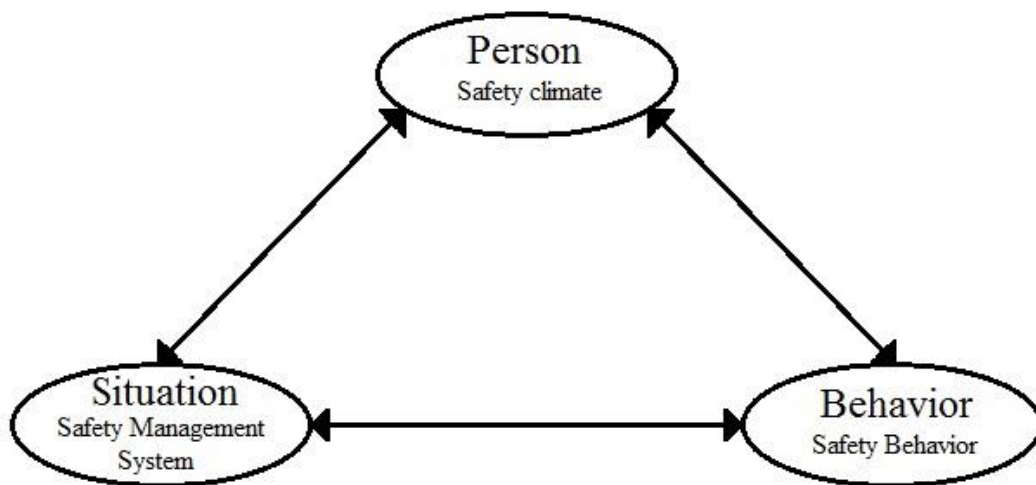


Figure (3.2) Reciprocal safety culture model.
(Cooper, 2000)

3.4. Safety climate

Safety climate is the reflection of the safety culture at a given time and place, (Dension, 1996). It can be described as “snapshot” of safety culture, (CANSO, 2008; Wiegmann et al., 2002). The first time the term safety climate appears was in a paper by Keenan in 1951. In many studies the term safety climate used interchangeably with the term of safety culture because safety climate also still does not have universal definition. Safety culture is more difficult to capture in an operational definition, (Guldenmund, 2010).

Table 3.2 gives collected definitions for the safety climate.

Table (3.2) Examples of safety climate definitions and their original references.

Original reference	Definition of safety climate
Zohar (1980)	<i>“A summary of molar perceptions that employees share about their work environments”</i>
Glennon (1982)	<i>“Employees’ perceptions of the many characteristics of their organisation that have a direct impact upon their behaviour to reduce or eliminate danger and, Safety climate is a special kind of organisational climate”</i>
Brown & Holmes (1986)	<i>“A set of perceptions or beliefs held by an individual and/or group about a particular entity”</i>
Dedobbeleer & Béland (1991)	<i>“Molar perceptions people have of their work settings”</i>
Cooper & Philips (1994)	<i>“Safety climate is concerned with the shared perceptions and beliefs that workers hold regarding safety in their work place”</i>
Niskanen (1994)	<i>“Safety climate refers to a set of attributes that can be perceived about particular work organisations and which may be induced by the policies and practices that those organisations impose upon their workers and supervisors”</i>
Coyle, Sleeman & Adams(1995)	<i>“The objective measurement of attitudes and perceptions toward occupational health and safety issues”</i>
Cabrera, Isla & Vilela (1997)	<i>“The shared perceptions of organisational members about their work environment and, more precisely, about their organisational safety policies”</i>
Williamson, Feyer, Cairns & Biancotti(1997)	<i>“Safety climate is a summary concept describing the safety ethic in an organisation or workplace which is reflected in employees’ beliefs about safety”</i>

Wiegmann et al. (2002) formulated a definition based on studying many definitions and finding the commonalities between them, the definition states that:

“Safety climate is the temporal state measure of safety culture, subject to commonalities among individual perceptions of the organization. It is therefore situationally based, refers to the perceived state of safety at a particular place at a particular time, is relatively unstable, and subject to change depending on the features of the current environment or prevailing conditions.” (p. 10)

3.5. The relationship between safety culture and safety climate

Sometimes both terms are used interchangeably but still both are considered to be different things. They cannot be considered the same, (Dension, 1996; Guldenmund, 2010).

Guldenmund (2010) presents common characteristics for safety culture and safety climate. The common characteristics for both concepts are as follows:

- 1- Both are a construct and abstract phenomenon.
- 2- Relatively stable.
- 3- Multidimensional.
- 4- Shared by group.
- 5- Functional.
- 6- Constitutes practices.
- 7- Consists of various aspects.

Safety climate can be seen as an indicator for the safety culture, (Cooper, 2000). Culture referred to deeper structure of the organization while climate

refers to the surface of the organizational life, (Dension, 1996). Safety climate may consider as the psychological aspect of safety culture, (Cooper, 2000).

3.6. Benefits of a good safety culture and safety climate

Good safety culture has high impact on increasing the productivity and reducing the cost on the long run, (Hudson, 1999). The Iceberg illustration can be used to show the cost and the causes of accidents. The direct cost and causes can be taken as the tip of the iceberg. The indirect cost and causes can be taken as the part of iceberg hiding under the surface, (Florczak, 2002).

The direct causes are the causes that can be seen in the front of the event. It can be an unsafe act or unsafe condition. The indirect causes are the causes behind the direct one. Indirect causes cannot be identified easily and it needs more investigation. Those causes include, but not limited to, lack of training, improper training, lack of awareness and being in a hurry, (Florczak, 2002).

As the causes divided into direct and indirect, the costs of accidents are also divided into direct and indirect. The direct costs are the costs for immediate action. Those costs include workers' compensation and medical payments. The indirect costs are the costs of the accident consequences on the long term. Those costs can include, and not limited to, loss of production, investigation cost and time spent for work related accident, (Florczak, 2002). The illustration of direct and indirect causes and accidents are shown in figure 3.3.

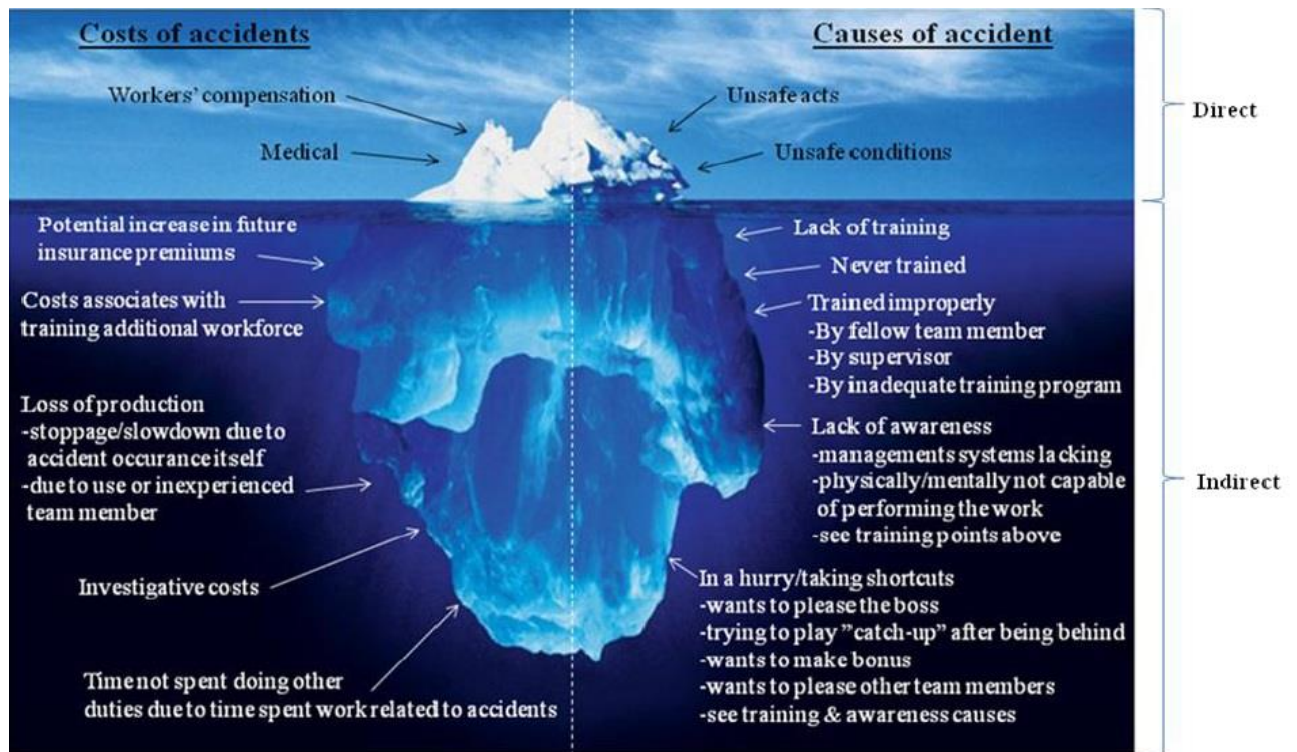


Figure (3.3) An illustration of direct and indirect costs and causes of accidents (Florczak, 2002)

In general, there are a lot of advantages of having good safety culture and climate. In power plants, as other industries, having a good safety culture is one of the most important concerns. Benefits of having a good safety culture in power plants include:

- Safety performance improvement.
- Reduce the losses from keeping the machines out of service.
- Ensure the continuous availability of electricity and water for all users.
- Avoid pain and suffering.
- Show the care from the company towards the employees.
- Win projects for new power plants.
- Build high reputation for the company.

3.7. Methods for evaluating safety culture

As mentioned earlier, the safety culture consists of three aspects. The first is psychological aspects (safety climate), the second is behavioral aspects and the third is situational aspects. Every aspect within safety culture requires different method to evaluate. The psychological aspects need questionnaire and interviews. The behavioral aspects need observations, safety audits and questionnaire. The situational aspects need observations and audits, (CANSO, 2008; Cooper, 2000)

So evaluating safety culture is difficult and a time consuming process. It needs many methods between quantitative and qualitative methods. Figure 3.4 presents the possible tools for evaluating each aspect of safety culture. Psychological aspects or safety climate is often used as an approximate evaluation of safety culture, (CANSO, 2008; Cooper& Phillips, 2004; Guldenmund, 2010).

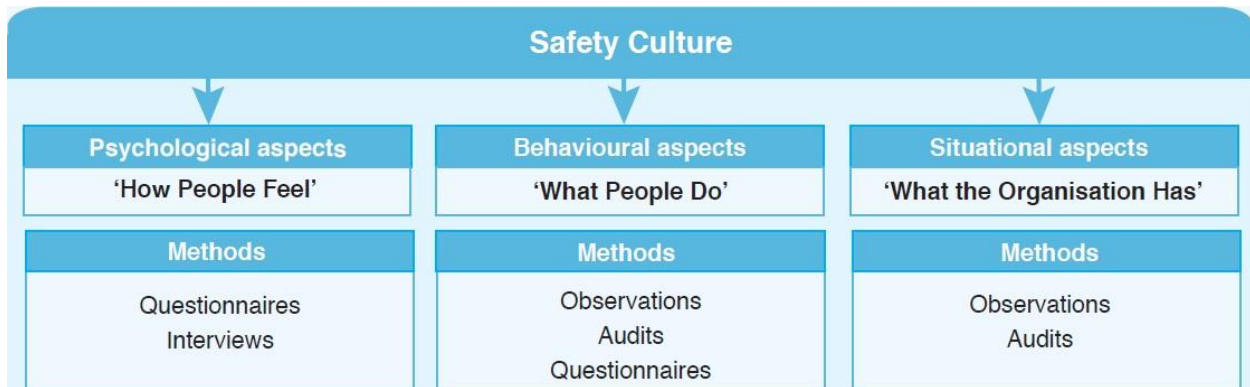


Figure (3.4) The possible tools for evaluating safety culture.
(CANSO, 2008)

To evaluate all aspects of safety culture, many resources are needed like accessing the database of the company, and using external resource such as a third party company which is considered to be a lengthy and costly process.

Selecting the tools to evaluate safety culture depends on what is needed to be evaluated and on the time and resources available, (CANSO, 2008).

In the present study, the safety climate is evaluated in order to give an image for the safety culture. Safety climate is an easy way to evaluate safety culture with low cost, less effort and minimal time. Safety climate can be evaluated by using questionnaire and interviews, which is considered as fast tools with low cost, (Cooper & Phillips, 2004).

3.8. Using questionnaire and interviews to evaluate safety climate

In the literature, it has been found that a questionnaire or interviews can be used alone or together in different orders to evaluate safety climate. In general, more than 80% of the researchers are conducting questionnaires as primary tools, after that they were conducting interviews as supportive tools, (Harris & Brown, 2010). The questionnaire is used for a large sample size and give quantitative results where the interview used for a small sample size and give qualitative results. Therefore, the researcher will decide to use which method or both in such an order (Harris & Brown, 2010). For safety climate measurement, it is important to find out a quantitative method in order to state the level of safety climate (Andy & Wadsworth, 2009). The studies in the safety climate fields showed that around 90% are using questionnaire alone and around 10% using both questionnaire and interviews (Andy & Wadsworth, 2009). In the present study, for evaluating safety climate, the questionnaire is used as a primary tool in order to quantify the safety level. In addition, it is targeting the highest number of participants to insure higher accuracy of the results. Furthermore, the interviews are used

after the questionnaire in order to support the results of the questionnaire and to give more explanation which insures the reliability of the results.

3.9. Questionnaire as a method

Questionnaire is a group of questions has been prepared to ask a number of questions and collect answers from respondents relating to the research topic, those questions usually come in printed or electronic form and sometime with blank to allow the participant to write his/her opinions or answer. Sets of such forms are distributed to groups and the answers are collected in order to analyze it later on to obtain statistically useful information about a given topic, (Ivancevich & Konopaske, 2013). There are two broad classes of questionnaires: descriptive and analytical. Descriptive questionnaires are usually limited to factual information, often biographical, which is usually accessible by other means. The other one is analytical questionnaires, which deals more with information related to opinions or attitudes. When a questionnaire properly constructed and responsibly administered, it can be used as a vital scientific instrument to obtain data from a large numbers of individuals, also statements can be made about specific groups of people or entire populations, (Kirklees, 2014). Construction of a useful questionnaire with minimum interfering problems requires skill, experience, thoughtfulness, and time. A useful method for checking a questionnaire and ensure it is capturing the intended information is to pretest among a smaller subset of target respondents. It serves four basic purposes: to (1) collect the adequate data, (2) make data comparable and ready to analyze, (3) ensure minimum bias in formulating and asking question, and (4) to make questions engaging and varied, (Ivancevich &

Konopaske, 2013). A major advantage of the questionnaire is that data can be obtained on a large numbers of participants quickly and relatively inexpensively. Further, the sample can be very large and geographically representative, anonymity can be easily maintained; that is, identifying information is not associated with the data. In addition, when constructed properly by performing a pilot study, the questionnaire provides data that can be organized easily, tabulated, and analyzed, because of these apparent advantages, the use of the questionnaire is a popular method. On the other hand, disadvantages can be experienced also in related to the questionnaire, as inappropriate questions, incorrect scaling, incorrect ordering of questions, or bad questionnaire format. Furthermore, the questions may be ambiguous or contain loaded words. All of this can make the survey valueless, as it may not reflect the views and opinions of the participants accurately. To avoid those disadvantages, pilot study should be performed on number of participants to seek their feedbacks, along with the feedback of experts in the field of the topic. The major drawback for questionnaire method has been given to response bias than to other sources of possible bias and contamination. Results can be affected by the sample on which they are based. The actual sample on which the data analyses are based is in general a subsample of the original sample. Low returns cause difficulty in assessing the representativeness of the final sample. It is safe to assume that it is biased and that those who participated in the survey are different in some way from those who did not, so it is important to calculate the return rate, (Ivancevich & Konopaske, 2013). If the return rate is higher than 70% then it is considered very good (Bergh, 2011). For this study, the return rate is 72.3%, and methods to increase the return rate include follow-up, general delivery and pickup, use of rewards for participation, use of closed-ended

rather than open-ended questions wherever possible, and limiting the length of time needed to complete the survey, (Ivancevich & Konopaske, 2013; Miller & Miller, 2004).

Since safety culture is expressed through safety climate, it was known to use the evaluation of safety climate as an approximation for safety culture evaluation, (Guldenmund, 2010; CANSO, 2008; Cooper, 2001).

Guldenmund (2010): *“Safety climate is generally explored through a questionnaire survey within the target organization or part of it”* (p. 71)

Safety climate questionnaire is a fast tool to evaluate safety culture as the safety climate is an indicator for safety culture, (Guldenmund, 2010; Cooper, 2001). Further, it is known that for collecting information from a large number of people, the questionnaire will be the best choice, (Guldenmund, 2010, Ivancevich & Konopaske, 2013). So, as discussed earlier, the questionnaire to be used in the presented work to evaluate the safety climate and indicate its level, with discovering the weaknesses within the safety system.

Safety climate questionnaire should consist of multi dimensions to evaluate different aspects in safety climate in order to know the weaknesses of the safety system, (Bergh, 2011; Guldenmund, 2010; Cooper, 2001). Clarke (2000) reviewed 16 studies in order to identify common safety climate dimensions. The studies include fields of nuclear plant, chemicals industry, aviation, railways and manufacturing. Clarke identified that five common dimensions were used in safety climate questionnaires as follow:

- 1- Safety management system
- 2- Individual responsibility
- 3- Work task/ work environment

- 4- Management attitudes
- 5- Management actions

Flin et al. (2000) performed a review for 18 studies. Those studies include fields of nuclear processing and laboratory, nuclear power plant, gas and oil processing, offshore oil drilling, chemical industry, manufacturing, aviation, construction, mining, food industry and steel factory. Flin et al. found six common dimensions as follow:

- 1- Management/Supervision
- 2- Safety system
- 3- Risk
- 4- Work pressure
- 5- Competence
- 6- Procedure/ rules

Guldenmund (2010) conducted similar research include 15 studies. Those studies include fields of chemical industry, mining, food industry, steel factory, petroleum, refinery, cement factory, construction, energy, healthcare, nuclear power plant and aviation. Guldenmund has identified six common dimensions as follow:

- 1- Management
- 2- Risk
- 3- Safety arrangements
- 4- Procedure
- 5- Training
- 6- Work pressure

Arghami et al. (2014) created a questionnaire for oil industry. The created questionnaire is based two safety climate questionnaires. The questionnaire contains the following dimensions:

- 1- Management Commitment to Safety and Personnel Collaboration
- 2- Safety Communication
- 3- Supportive Environment
- 4- Work Environment
- 5- Safety Training
- 6- Priority of Safety
- 7- Personal Priorities and Need for Safety

Researchers' team from Nordic Occupational Safety has developed a Nordic Safety Climate questionnaire which is called NOSACQ-50. This questionnaire is based on theory background of organizational and safety climate, and based on psychological theory, with previous researches and international studies in various sectors. NOSACQ-50 confirmed reliable and valid, and translated to 21 languages, (NOSACQ-50, 2015a). This questionnaire had seven dimensions as follow:

- 1- Management safety and ability.
- 2- Management safety empowerment.
- 3- Management safety judgment.
- 4- Workers' safety commitment.
- 5- Workers' safety priority and non-acceptance of risk.
- 6- Safety communication, learning, and trust in safety ability.
- 7- Workers' trust in the efficiency of safety system.

Table 3.3 shows a comparison for different dimensions combination that already stated earlier. The table shows commonalities between those dimensions.

Table (3.3) Comparison of the questionnaire dimensions

Dimensions	NOSACQ-50 (2015)	Clarke (2000)	Flin et al. (2000)	Guldenmund (2010)	Arghami et al. (2014)
Management	Management safety priority and ability	-Safety management system -Management attitudes	-Management/ Supervision -Safety system -Competence	-Management	-Priority of safety -Management commitment to safety
	Management safety empowerment				-Supportive environment
	Management safety judgment	-Management actions			
Workers	Workers' safety commitment	-Individual responsibility			
	Workers' safety priority and risk non-acceptance	-Work task/work environment	-Risk -Work pressure	-Risk -Work pressure	-Personal Priorities and Need for Safety - Work environment
	Safety communication, learning, and trust in safety ability		-Competence	-Training	-Safety training -Safety communication
	Workers' trust in the efficiency of safety system				
Others			-Procedure/ rules	-Procedure	
				-Safety arrangements	

A discussion has been done with the Company safety department representatives and managers of other departments. After discussion, all agree to choose NOSACQ-50 as its dimensions are comprehensive. It had been decided to use this questionnaire as mainframe to create own questionnaire.

So in the presented work the formulated questionnaire will be based on the structure of the NOSACQ-50 with many modifications by the help of Al Ezzel O&M safety, operation and maintenance representatives. The modifications include changing some questions as well as changing wordings of many questions in order to further clarify the questionnaire. By all of this, the questionnaire has been ensured to suit the company as it is agreed by different departments' representatives.

3.10.Interviews as a method

Interviews are widely used technique for collecting data for small group of people. In the interview, the interviewer will talk face to face with interviewees or people involved in the research in order to seek their opinions or to get clarification of different issues. The interviews can be conducted with a single person or with a group of individuals, (Ivancevich & Konopaske, 2013). First type of interviews is the unstructured interview that has no predetermined or pre-prepared questions, which increase the chance to ask different questions for each person. In addition, there are structured interviews, the interviewer has predetermined and specific list of questions to ask of all interviewees. During the interviews, the questions itself can be either closed-ended, where the individual answers will be a selection from a set of options or answers, or open-ended questions, where the respondents

answered by their own words, (Campion et al., 1994). A major advantage of the interviews is that data can be obtained face to face that prevent misinterpretation, as the interviewees can directly ask questions and clarify any doubts and the interviewers can give direct clarifications or corrections to any misunderstood points as well. Further, interviews allow the data collectors to explain how the information gained from the interview will be used, also if they used the structured interview type that will ease the process of respondents' answers comparison, (Ivancevich & Konopaske, 2013). This method also will prevent the response and sampling bias caused by low return problems, for the reason that the data will be collected immediately (immediate response). One of the disadvantages that can be experienced in this method is the inability to return back to the answers as there is no hard copies for the answers like the one in the questionnaire and that can lead to inaccurate or unreliable results, because interviewers can intentionally or unintentionally distort the provided information, (GAO, 1991). As the interviews will be conducted face to face between the interviewers and respondents, anonymity is difficult to maintain, that does put more pressure on individuals, limit their freedom, and influence the way they respond to questions. Therefore, they are more likely to modify or distort their answers to match it with interviewers' needs and beliefs and that in turn affects the reliability and accuracy of the results. Although interviews are one of the effective ways to collect data, it is also time consuming for all parties. When data collectors used the unstructured interview type, there will be big opportunity to gather different types of information from each interviewee, which makes it difficult for the interviewers to compare the data and finalize the results. Finally, this method will allow bias to appear more than any other methods, because it allows direct contact between interviewers and

respondents, which lead to more personal judgment that is influenced by the respondent appearance, position, and non-verbal behaviors as well as the common similarities between the interviewers and interviewees, (Ivancevich & Konopaske, 2013).

As mentioned earlier, the primary way of evaluating the safety climate is the questionnaire, the secondary way are interviews, (CANSO, 2008; Bergh, 2011). Interviews had been used in 10% of safety climate studies, (Andy & Wadsworth, 2009).

3.11.Directions of safety climate studies

Safety climate studies started at 1980 by Zohar, and the studies still going on to discover new issues within this subject. As well as safety climate, safety culture also is considered as new concept since it appeared first time after Chernobyl accident in 1986, (INSAG-1, 1986). In addition, several studies were relating safety climate to safety culture and many times both concepts were used interchangeably, (Guldenmund, 2010).

By referring to various studies, one can find that safety climate studies cover many aspects within safety climate concept. The studies in this field went into different directions; some studies cover the definition and the descriptions of the safety climate, (CANSO, 2008; Cooper, 2000, 2002; Wiegmann et al., 2002; Schein, 1992, 2010; Reason, 1997; Guldenmund, 2010). Other studies focused on the effect of safety behavior and accidents on the safety culture, (Cooper, 2004; Sorensen, 2002; Reason, 1997; Guldenmund, 2010; Hudson, 1999). Also many studies concerned about the way of measurement of safety culture and the aspects to be taken in order to

achieve the best measurement methods with the designing of measuring tools such as questionnaires, which considered the main tool to measure the safety climate. (Andy & Wadsworth, 2009; Cooper, 2001, 2004; Guldenmund, 2010; Sorensen, 2002; Flin et al., 2000; Clarke, 2000; Prasad & Reghunath, 2010; Arghami et al., 2014). As adoption of the previous work, some studies used the pre-established tools with modifications in order to apply it and evaluate or measure the safety climate, (Collins & Gadd, 2002; Bergh, 2011, Bergh, Shahriari & Kines 2013; Guldenmund, 2010; Milczarek & Najmiec, 2004; Wu, Liu & Lu, 2007). The final step in the process of studying the safety climate is the enhancement of the safety culture, and this part was conducted by some studies and still going on as it is the target of studying the safety culture or climate. (CANSO, 2008; Shirur & Torgal, 2014; Hudson, 1999; Cooper, 2001, 2013; Mathis & Gallawy, 2013).

The aspect chosen by the researcher depend on the interest of the researcher, the situation when conducting the study, the available time and the availability of the resources.

3.12.Safety climate: fields of study

The studied fields varied depending on the connection between the researcher and the field itself. The studies covered many field such as: construction, (Prasad & Reghunath, 2010; Zacharatos & Barling, 2005; Shirur & Torgal, 2014; Dedobbeleer & Beland, 1999), chemical industries, (Bergh, 2011, 2013; Flin et al., 2000; Zacharatos & Barling, 2005), aviation, (CANSO, 2008; Wiegmann et al., 2002; Eiff, 1997; Ciavarelli & Figlock, 1996), service companies (Guldenmund, 2010), nuclear power, (Sorensen, 2002; Carroll, 1998; Lee, 1998; Wilpert, 2000), offshore and oil & gas

industry, (Cox & Cox, 1991; Cox & Cheyne, 2000; Flin, Mearns, Gordon, & Fleming, 1998; Arghami et al., 2014), transportation, (Mcdonald & Ryan, 1992; Meshkati, 1997), mining, (Griffin & Neal, 2000), food industry, (Zohar, 1980), and conventional power (Yule, Flin & Murdy, 2001).

3.13.Focus of current study

The main concern of the presented work is the evaluation of safety climate for a power plant by designing a measuring tool based on literature review and previous studies. The presented work evaluates the safety climate for oil and gas fired power plants. By referring to the literature review, it has been found that the studies related to conventional power production were rare, which is considered as a gap in the safety climate studies for the industrial sector. The importance of this work is related to the importance of the power production sector. The power production is an essential industry to ensure the continuity of most of modern operations in the society as well as the industrial sector itself. In addition, most of the studies were conducted in Europe, USA, and east of Asia. Further, in Gulf Cooperation Council (GCC) countries, no such study has been found. So by conducting the study in Bahrain, new culture will be added to the studies of safety culture worldwide.

To conclude, the current study is focusing in filling some gaps in the safety climate studies, which are studying the safety climate in conventional power plants, designing measuring tools for safety climate especially the interview questions, and conducting the study in new culture, which is the Middle East culture.

3.14.Summary

Safety is the most important subject in the industrial sector, such as gas fired power plants. To measure the safety level, it is better to use leading indicator, which can detect the weaknesses in the safety system and rectify it before an accident occur. One of the leading indicators is the safety culture, which can be measured approximately by safety climate. Safety climate can be measured by a questionnaire, which considered as the main tool for measuring the safety climate. Where there is a secondary tool that is the interviews that used to support the questionnaire results. Safety climate is relatively a new field in the world and in the GCC countries, which makes it interesting to investigate with its relation to main safety issues.

Chapter four

Methodology

4.1 Procedure of present study

4.2 Questionnaire

4.3 Interviews

4.4 Sampling method

4.5 Data Analysis

4.6 Defining safety culture

4.7 Conducting safety workshop

4.8 Seeking solutions for improving safety culture

Chapter four

Methodology

4. Methodology

The general steps of the presented study start with performing a literature review to get an idea about the targeted company, safety culture, safety climate and the methods to evaluate safety climate. Next, a meeting was arranged with the general manager and the head of health, safety and environment (HSE) department. Then, the measuring tool design process has been used through multi stages. The final step was conducting questionnaire to evaluate the safety climate level and conducting interviews to validate the questionnaire results and have a better understanding of them.

4.1. Procedure of present work

A meeting was held with the general manager to introduce the idea and to get the permission for performing the study on power plant. A second meeting was held with the head of HSE department in order introduce the idea and seek the feedback about the methods to be used.

After that, discussion had been made with representatives of HSE department and managers of other departments to decide on the wanted questionnaire dimensions. Then, the questionnaire has been designed based on the feedback from the HSE department and by performing pilot study.

After designing the questionnaire, it were handed to every employee in Al Ezzel power plant, and Al Dur power plant and water production sites personally. Everyone received the questionnaire was informed about the aim

of the questionnaire and the benefit of the presented work. The participants had been told to not write their names. In addition, they had been informed that the material is confidential, and nobody can see the individual results. The questionnaire were collected personally as handed.

Around 210 questionnaires were distributed among all the employees. The return rate was 72.3%. All data collected were treated confidentially which means only the author can see the raw material, which kept locked up in a safe place. Later all raw data have to be destroyed as per the company request.

For the interviews, 30 employees were selected by stratified sampling method. Then, they were asked through emails if they like to participate. The rate of responses for the interviews was 33.33% of the chosen employees. The chosen employees were presenting good mixture from the two plants. Some participants agreed on recording the interview and some requested only to take notes. All the material –as the same as the questionnaire- were treated confidentially and kept locked up, and will be destroyed at end of the research as per the company request.

4.2. Questionnaire

4.2.1 Questionnaire initial construction

After the literature review and the feedback of HSE department, a questionnaire was formulated based on specific factors by referring to set of questionnaires that confirmed reliability and validity to ensure the questionnaire fit to what needed for. The primary questionnaire was chosen based on the review of set of questionnaires and by involving the HSE

department, then many modifications has been done by comparison with other questionnaires and by seeking feedback of HSE department.

For the present work, set of questions has been prepared to collect information related to the safety climate. Structured questionnaire had been used with close ended questions and one open-ended question. The questionnaire was distributed by hand to increase the rate of return.

4.2.2 Validity of the questionnaire

Validity is the degree in which a questionnaire measures what it is intended to measure, and the validation process is to insure that it measures what it aims to do, (Edwards, 2010). The validation process had been done through two steps. In the first step, it was seeking feedback of HSE department as an expert in the field. In the second step, a pilot study was carried out to improve the questionnaire.

A pilot study to be conducted in order to identify any mysterious questions, spot the weaknesses, insure easy wording and estimate the time required for questionnaire completion. The pilot study included 20 participants. According to Connelly (2008), 10% of the total population is ideal to be used for a pilot study. The pilot study repeated two times; every time, notes were taken to modify the questionnaire, then the final version had been completed. The average time required to finish the questionnaire was calculated. The time was 10.6 minutes.

4.2.3 Reliability of the questionnaire

Reliability is the degree in which a questionnaire can return similar results when repeated for the same population, (Edwards, 2010). There are two types of reliability: stability and internal consistency.

Stability is getting the same results for the questionnaire if conducted twice for the same population with lapse of time, (Esposito, 2002). In the presented study, to check the questionnaire stability, test and retest has been done. The numbers of participants were similar to the pilot test and 20 participants were chosen randomly. For the time between the two trials, there were no evidence for the correct time (Parsian & Dunning, 2009), so it is better not to make it long or short in consuming time. In this study, the time has been set to ten days. The Interclass Correlation Coefficient (ICC) has been used in order to determine the stability of the questionnaire, which reflects its reliability. The stability has been found to be between 0.495 and 0.751, which is considered moderately stable, (Kines et al., 2011; Kufs, 2010).

The internal consistency is the degree of matching between the questions and subject, (Pallent, 2007). Internal consistency has been calculated using Cronbach alpha coefficient. This method requires large number of samples (Yurdugul, 2008). Therefore, the test has been done after collecting all the questionnaires to include all the population (around 150 participants). The results of the test were between 0.55 and 0.81, which considered as acceptable, (Pallent, 2007).

4.2.4 Questionnaire dimensions and structure

As mentioned earlier, different questionnaires had been reviewed with the HSE department. Different questionnaires were presenting different combination of dimensions. After discussion with HSE department about the dimensions of different questionnaires, NOSACQ-50 had been chosen as the main structure for the present work questionnaire. NOSACQ-50 was developed by Nordic research network of occupational safety researchers

and Nordic council of ministers, (NOSACQ-50, 2015a). The developing team includes scientists, psychologists and safety experts. They design the questionnaire based on organizational theory, safety climate theory, psychological theory, previous researches and studies, and continuous development process of the questionnaire, (NOSACQ-50, 2015a; Kink, 2010; Bergh, 2011).

Modifications were done to the questionnaire while keeping the main structure. The modifications were done with the help of HSE department, the pilot study and by comparison with other safety climate questionnaires in order to formulate a questionnaire that fit to the power plant.

The questionnaire consists of seven dimension and fifty items, all items are five points Likert scale and it consists of positive and negative questions. The positive questions scored from 1 to 5, with 1 for strongly disagree and 5 for strongly agree. The negative questions scored inversely from 5 to 1, with 5 for strongly disagree and 1 for strongly agree. A mean score over 3 is considered positive result since it is the mean value between the highest and lowest scores (NOSACQ-50, 2015b; Kink, 2010; Bergh, 2011; Cooper, 2001). In addition to the fifty questions, the questionnaire contains background questions to use it in determining the factors that affect the safety climate level. A sample of used questionnaire in the presented work is shown in appendix B.

The structure of the questionnaire is shown in figure 4.1. The seven dimensions and their aspects are listed below:

- 1- Management safety priority and ability:
Workers' perceptions of how management:
 - Prioritize safety.
 - Actively promote safety and react to unsafe behavior.
 - Show competence in handling safety.

- communicate safety issues.
- 2- Management safety empowerment:
Workers' perceptions of how management:
 - Empower workers.
 - Supports participation.
- 3- Management safety judgment:
Workers' perceptions of how management:
 - Treat workers involved in accidents fairly.
- 4- Workers' safety commitment:
Workers' perceptions of how they:
 - Show commitment to safety.
 - Actively promote safety.
 - Care for each other's safety.
- 5- Workers' safety priority and risk non-acceptance:
Workers' perceptions of how they:
 - Prioritize safety over production.
 - Do not take risk or accept hazardous conditions.
- 6- Peer safety communication learning and trust in safety ability:
Workers' perceptions of how they:
 - Discuss safety issues whenever such emerge.
 - Learn from past experience.
 - Help each other to work safely.
 - Treat safety suggestions from each other.
 - Trust each other's ability to ensure safety.
- 7- Workers' trust in efficiency of safety systems:
Workers' perceptions of how they:
 - Consider formal safety systems effective, e.g. safety representatives and safety rounds.
 - Experience benefit from early planning.
 - Experience benefit from safety training.
 - Experience benefit from clear safety goals and objectives.

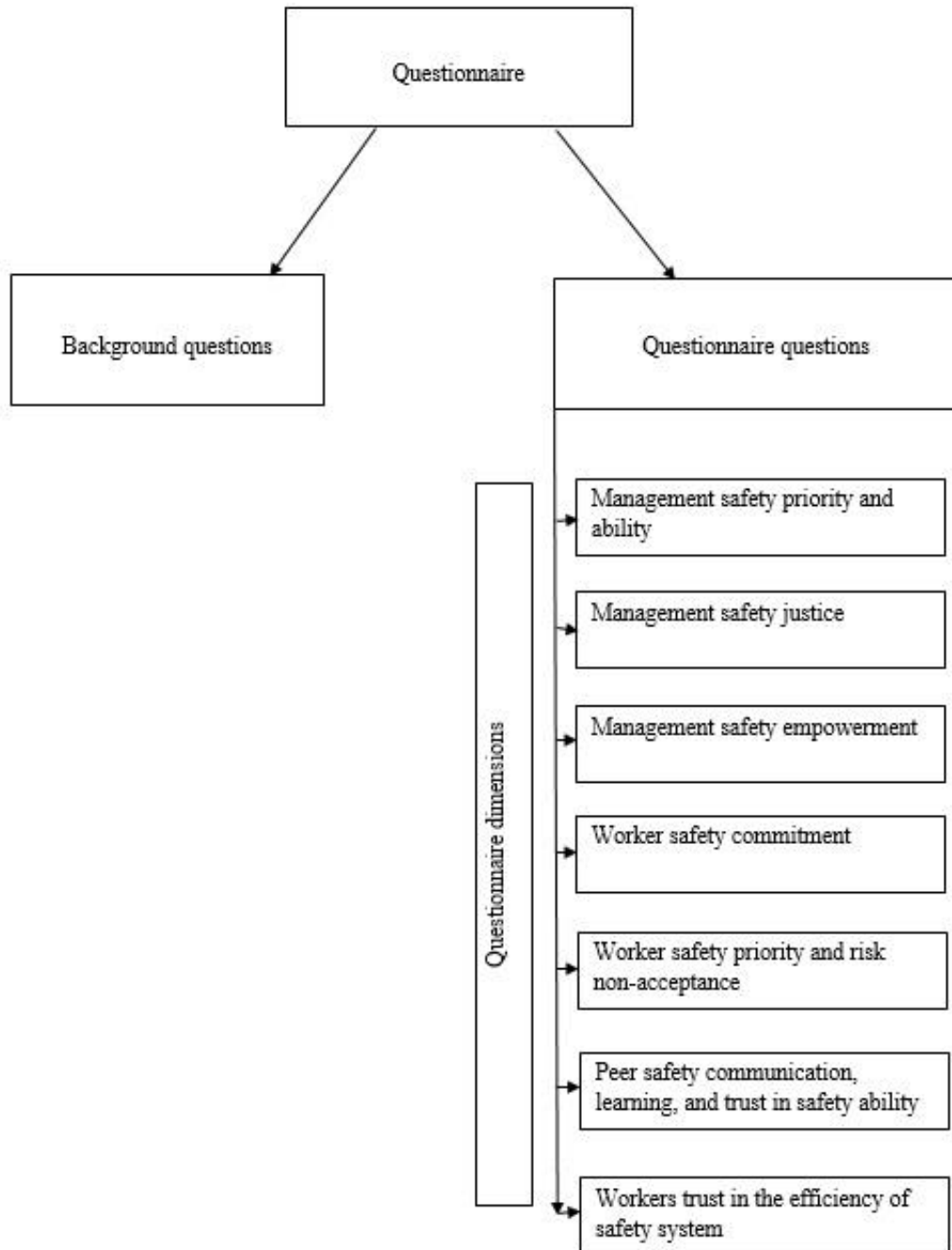


Figure (4.1) The questionnaire structure and dimensions for the present work

4.3 Interviews

In the presented study, the interviews are structured, single, and it consists of open-ended questions. It is structured in order to limit the time required for the interview. In addition, it is single which increase the level of confidentiality and allow the interviewee to talk freely. Finally, it consists of open-ended questions to seek the opinions of the interviewee.

The interview questions are based on the questions of the questionnaire. The interview questions were used to seek more explanation to some items in the questionnaire in order to analyze the results of the questionnaire. In addition, some of the questions are based on the results of the questionnaire in order to discuss the results (the discussion of the results are presented in chapter 6). For example, question 12 of the interview is used to cover dimension seven and it based on the question 47 of the questionnaire. Question number 12 of the interview is: What is the effect of safety rounds on safety? Moreover, it is related to question number 47 of the questionnaire, which is: We who works here consider that safety round/ evaluations as a help to find serious hazards.

As the same as the questionnaire, the interview questions were designed by the help of HSE department as the head of HSE emphasized on the importance of the interviews.

The interview questions are shown in appendix C.

4.4 Sampling method

In a research, the targeted population should be defined clearly. There are no standards or rules that may be used in order to define the targeted population. The targeted population is subjected to the researcher judgment

with keeping in mind that the targeted population is related to the objectives of the research, (Statpac, 2014).

The population size will either be small or large. If the population is small, the researcher can include all the population, this research is called census study. If the population is large, the whole population cannot be covered by the questionnaire, in this case a small sample should be chosen carefully to reflect the characteristics of the population, (Statpac, 2014; Herbert, 2005).

There are two types of sampling methods, probability sampling and non-probability sampling. In probability sample, the chosen samples have an equal probability to be selected. This type of sampling includes random sampling, stratified sampling, cluster sampling, multistage sampling, and systematic sampling. In non-probability samples, the chosen samples will be subjected to certain procedure or will be chosen non-randomly. This type of sampling includes convenience sampling, quota sampling, judgment sampling, voluntary sample, snowball sampling, and accidental sampling, (Statpac, 2014; Stattrek, 2016).

4.4.1 Probability samples

Random sampling: The selected members have exactly the same chance to be selected without any bias. This is considered as pure sampling method because there is no basis of the selections, just randomly, (Statpac, 2014).

Systematic sampling: It is similar to random sampling with more simplicity. After calculating the sample number (N) within the population (n), list of all population will be created, then a random sample will be chosen from the list, after that a sample will be taken from the list every (n/N) till the number of samples finished, (Black, 2004).

Stratified sampling: The targeted population will be divided into groups (strata) that share common characteristics, then random selection to be

applied to each stratum. This method has the advantage of reduced sampling error, (Statpac, 2014; Stattrek, 2016).

4.4.2 Non-probability samples

Cluster sampling: The members of the population will be assigned to one cluster, then a cluster will be chosen randomly and apply the survey only for the individual of the chosen cluster, (Stattrek, 2016).

Multistage sampling: Is the using of combination of methods in stages in order to achieve the final samples. For example, in stage one the cluster sampling used to choose set of members, and then in stage two random samples used to choose from the chosen clusters, (Stattrek, 2016).

Convenience sampling: A convenient samples or easy to reach to be chosen and used as approximation for the rest of the population. For example, one factory selected because it is easy to reach and then the result reflect the all population. This method used to reduce the cost and the time of random selection, (Statpac, 2014; Stattrek, 2016).

Judgment sampling: It is similar to convenience sampling in some way but with the judgment of the researcher in selection based on his confidence that the selected group is reflecting all the population and not based on the easiness to reach, (Statpac, 2014).

Quota sampling: It is similar to stratified sampling but in non-probability way. The population will be divided into strata, then the selection within each stratum will be by convenience or judgment sampling, (Statpac, 2014).

Snowball sampling: Is used for samples with rare characteristics. Initial sample to be found, then the next sample will be introduced by the previous one and so on. This method used to reduce the cost and time of searching about rare samples, (Statpac, 2014).

Voluntary sample: A survey to be announced, and people who interested will volunteer to participate. This method used to insure gathering samples with strong interest to the subject, (Stattek, 2016).

Accidental sampling: The researcher will use the available samples till the desired sample size reached. In this method there is no assurance that the selected samples represent the entire population and this is the least used method, (Connaway & Powell, 2010).

For the present work, the population is small, which can be included all. Therefore, all the population (total number of workers) is included for the questionnaires in this work, which called census study. By including all the population (or all workers), the accuracy of the results can be increased. Sample size, which is equal to the population size, is around to 210 employees (the exact number not provided for confidentiality reasons). For the interviews, stratified sampling method is used to insure that the chosen employees represent all the departments. The employees are divided into groups according to their departments. Then every group is assigned with equal number of samples. Finally, a random selection was carried out for each group. The sample size for the interviews is 30 (around 14% of total number of employees). This sample size had been decided after comparison with previous studies.

4.5 Data Analysis

The collected data of the questionnaire were analyzed by Microsoft Excel software. The analysis process was done using different formulas in Excel software to calculate mean score value, perform T-test, calculate Cronbach alpha coefficient and Interclass correlation coefficient. All formulas are shown in appendix F. The raw data were used to calculate the mean value

for each dimension for every submission, than the overall and groups mean score were calculated based on the individual results for each dimension (Prasad & Reghunath, 2010, Cooper, 2001).

The mean score for all dimensions are presented in the result chapter displayed as radar chart. Radar chart is 2-dimensional chart used to display variables more than two in a way to identify the gaps between two or more groups, which help to determine the strengths and weaknesses (Chandoo, 2008; Friendly, 1991). Every two groups examined for significant difference using T-test with 95% level of confidence and P-value (probability value) less than 0.05 to consider the test is significant. In the results chapter, any non-significant P-value is referred as non-significant (NS). For T-test the sample size of the two groups are not necessary to be equal, (Miller & Miller, 2004).

The internal consistency of each dimension tested using Cronbach alpha coefficient (equation 4.9) which is called coefficient of reliability, the value of coefficient is greater than 0.7 which is considered to be ideal and reliable (Pallant, 2007; George & Mallery, 2003, Gliem & Gliem, 2003). For the presented work, the average Cronbach alpha coefficient is 0.73, which is considered to be ideal and reliable. In addition, Interclass Correlation Coefficient (ICC) is used to determine the stability of the questionnaire, which reflects its reliability (equation 4.15).

For analyzing the interviews, content analysis has been used, (Graneheim & Lundman, 2004). Content analysis is qualitative research method used to interpret the meaning of texts. In the presented work the text is based on the interviews conducted. Content analysis is shortening the text by reduction, distillation or condensation. The analysis is focused on the manifest content of the questions. The answers were summarized into meaning units, which

are group of words, or statements which related to the same central unit (Graneheim & Lundman, 2004; Bergh, 2011; Elo & Kyngas, 2008; Mayring, 2000). The interview questions are shown in appendix C. The summary of the answers are shown in table 5.18 in the results chapter.

4.5.1 Mean score value

For calculating the mean score of the dimensions, every answer is assigned with weight of 1 to 5. The following is the way of calculation of all dimensions with using letter Q for the answer followed by a number representing the item number (e.g. Q8 is the answer for question 8). If the item is positive, its weight is calculated directly (1 to 5). If the item is reversed, its weight is reversed (5 to 1) by subtracting the weight from 6. Because if the item is reversed that means that the highest weight should be assigned to 1 and the lowest weight should be assigned to 5, and by subtracting the answer from 6, the item weight will be reversed and reflect its true value. Table 4.1 shows the way of calculating the mean score.

Table (4.1) The calculation of mean score value

Dimension	Mean score calculation
1- (Q1-Q9)	$(Q1 + Q2 + (6-Q3) + Q4 + (6-Q5) + Q6 + Q7 + Q8 + (6-Q9)) / 9$ (4.1)
2- (Q10-Q16)	$(Q10 + Q11 + Q12 + Q13 + Q14 + (6-Q15) + (6-Q16)) / 7$ (4.2)
3- (Q17-Q22)	$(Q17 + (6-Q18) + Q19 + Q20 + (6-Q21) + Q22) / 6$ (4.3)
4- (Q23-Q28)	$(Q23 + Q24 + Q25 + (6-Q26) + Q27 + (6-Q28)) / 6$ (4.4)
5- (Q29-Q35)	$((6-Q29) + (6-Q30) + (6-Q31) + (6-Q32) + Q33 + Q34 + (6-Q35)) / 7$ (4.5)
6- (Q36-Q43)	$(Q36 + Q37 + Q38 + Q39 + Q40 + Q41 + (6-Q42) + Q43) / 8$ (4.6)
7- (Q44-Q50)	$(Q44 + (6-Q45) + Q46 + Q47 + (6-Q48) + (6-Q49) + Q50) / 7$ (4.7)

Q = Answer weight, e.g. Q9 is weight of answer 9.

Any weight subtracted from 6 (e.g. 6-Q28), it represent reversed question.

An example for calculating the mean score of single dimension is shown in appendix D.

4.5.2 Radar chart

Radar chart is 2-dimensional chart used to display several factors related to one item to identify the weaknesses and strengths, (Skymark, 2016). It is used also to compare two or more options for multivariable data in order to show the differences, and decide on which option to choose, (Chandoo, 2008). However, there is a limitation in using this approach, because sometime an option shows higher values in many variables while shows lower values in some variables which make it difficult to decide on which option is better, (Chandoo, 2008). The main advantage of using radar chart is the ability to represent more than three variables in a way that shows the similarities or differences, which are useful in the presented study as seven variables are used. In addition, it helps in comparing between two or three groups. Comparing the radar chart to the histogram, the histogram has limitation to the number of the variables, while the radar chart is used for more variables in an easy and clear illustration.

The shape of the radar chart is the same as the spider net with the center having low value and the edges have high value, (Nist, 2003). Figure 4.2 shows a general example of using radar chart and figure 4.3 shows an example of the radar chart for a result of the present work, which is the variation in the level of safety climate between Al Ezzel site and Al Dur site. Radar chart is helpful with small to moderate set of data, (Nist, 2003), so the number data set is limited, but in the presented study it is helpful because the multivariable or factors to be used are seven only - dimensions of the questionnaire - and the maximum number of items or options are three.

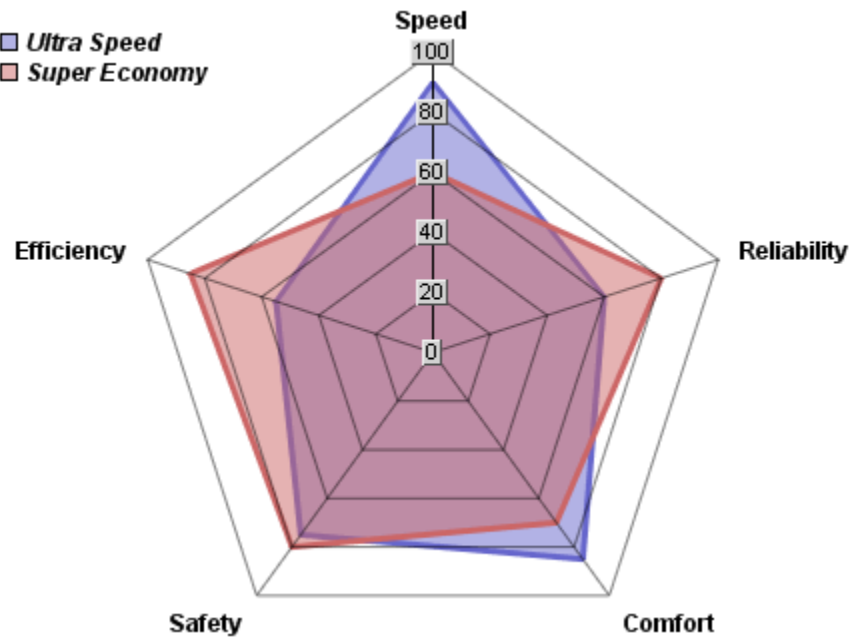
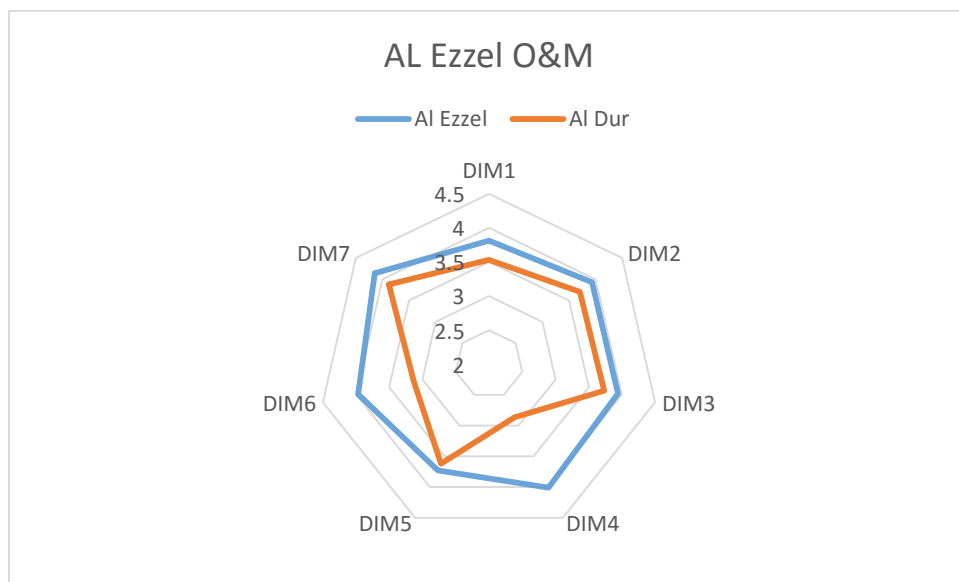


Figure (4.2) Radar chart showing a comparison between ultra-speed cars and super economy cars using five factors.
(Chart adopted from (Advsofteng, 2012))



DIM = Dimension

Figure (4.3) The variation in the level of safety climate between Al Ezzel and Al Dur.

4.5.3 Hypothesis test

Hypothesis test is a statistical test applied to experimental data against some criteria to decide if the experimental results are true or not, by other words it is used to determine whether there is enough evidence in a sample of data to conclude that a certain condition is true for the entire population, (Miller & Miller, 2004; Minitab, 2015).

In the presented study, hypothesis test is needed in order to check if there is a significant difference between the mean values of two groups. Two widely used hypothesis tests in researches are chi-square test and T test. Both tests are designed to test null hypothesis. Null hypothesis is a statement that indicates that something is zero or does not exist. For the presented study the test indicates that there is no difference between the mean values (zero) or the difference is significant (not equal to zero).

Chi square test examines a null hypothesis for two variables for different responses or levels, which is considered as categorical data. Chi square compares observed frequencies against expected frequencies difference, (Miller & Miller, 2004).

T-test is used to test the null hypothesis for means of two groups. T-test is used for quantitative variables that are estimated by the mean value with only two levels, (Miller & Miller, 2004).

In the present study, a comparison was made between two groups for their mean values and not against expected value. This make clear idea about the suitable test to be used, so in the presented study, T-test is used because the result of safety climate is shown as mean value which is suited to use the T-test.

The state of T-test hypothesis is as follows (Miller & Miller, 2004; Stone & Ellis, 2006):

$$Z = (\bar{x}_1 - \bar{x}_2) / \sqrt{(\sigma^2_1/n_1 + \sigma^2_2/n_2)} \quad (4.8)$$

Where:

$\mu_1 - \mu_2$: Difference between mean values of two groups

μ_1 : Mean value of first group

μ_2 : Mean value of second group

$\bar{x}_1$: Calculated mean value of first group

n_1 : Number of samples of first group

σ^2_1 : Variance of first group

$\bar{x}_2$: Calculated mean value of second group

n_2 : Number of samples of second group

σ^2_2 : Variance of second group

Z: The standard difference between the observed values and its hypothesized population parameter in units of the standard deviation

Null hypothesis: $\mu_1 - \mu_2 = 0$

Alternative hypotheses: $\mu_1 - \mu_2 \neq 0$

As μ and $\bar{x}$ are the same and σ^2 is known, using Z value, P-value (probability value) is determined by using the standard normal distribution table, then P-value is to be compared with α (α =100-confidence level), if $P < \alpha$ then the difference between the samples mean is significant, and if $P > \alpha$ then the difference between the samples mean is not significant, (Miller & Miller, 2004; Chem, 2006).

4.5.4 Cronbach coefficient

Cronbach's alpha is statistical test used to measure the internal consistency or reliability of set of data with multi tasks. The coefficient (r_α) is calculated as follow (Easycalculation, 2015; Gliem & Gliem, 2003) in conjunction with equation 4.9 and table 4.2:

$$r_\alpha = (K/(K-1)) (1 - (\sum \sigma^2_i / \sigma^2)) \quad (4.9)$$

Table (4.2) The calculation way for Cronbach alpha coefficient

Participant	Q ₁	Q ₂	Q _i	Total score
P ₁	a ₁	b ₁	c ₁	T ₁ =a ₁ +b ₁ +c ₁
P ₂	a ₂	b ₂	c ₂	T ₂ =a ₂ +b ₂ +c ₂
P _i	a _i	b _i	c _i	T _i =a _i +b _i +c _i
variance	$\sigma^2_1 (a_1, a_2, a_i)$	$\sigma^2_2 (b_1, b_2, b_i)$	$\sigma^2_i (c_1, c_2, c_i)$	$\sigma^2 (T_1, T_2, T_i)$

Q = Question. a,b,c = score of the question.

Where:

Q: Question

P: Participant

T: Total score for the participant

K: Number of questions (Q_i)

σ^2_i : Variance of Q_i

σ^2 : Variance of participant (P_i) total scores (T_i)

r_α : Cronbach alpha coefficient

The value of alpha coefficient ranges from 0 to 1, the greater value represents higher reliability. Most of the researchers agreed that alpha coefficient value around or more than 0.7, which means that the result is ideal and reliable. The following is the scale of the coefficient that can be considered as rules of thumb: $r_\alpha > 0.9$ is Excellent, $r_\alpha > 0.8$ is Good, $r_\alpha > 0.7$ is Acceptable, $r_\alpha > 0.6$ is Questionable, $r_\alpha > 0.5$ is Poor, and $r_\alpha < 0.5$ is Unacceptable, (Pallant, 2007; George & Mallery, 2003, Gliem & Gliem, 2003). Table 4.3 gives an example by numbers for the calculation way of Cronbach alpha coefficient.

Table (4.3) Example with numbers for the calculation way for Cronbach alpha coefficient

Participant	Q ₁	Q ₂	Q _i	Total score
P ₁	4	5	5	14
P ₂	3	3	4	10
P _i	2	2	5	9
variance	$\sigma^2_1 = 0.667$	$\sigma^2_2 = 1.556$	$\sigma^2_3 = 0.222$	$\sigma^2 = 4.667$

Q = Question.

Using equation 4.9

$$K=3$$

$$\sigma^2_1 = 0.667$$

$$\sigma^2_2 = 1.556$$

$$\sigma^2_3 = 0.222$$

$$\sigma^2 = 4.667$$

$$r_\alpha = (3/2) (1 - (2.445/4.667)) = 0.71$$

$r_\alpha = 0.71$ is considered as an acceptable value for Cronbach coefficient according to the classification discussed above.

4.5.5 Interclass Correlation Coefficient

Correlation coefficient is a coefficient that is used to find statistical relationships between two or more random variables or observed data values, by other words, it will indicate the degree of the likelihood between two or more set of data. The type of correlation used in the presented work is called Interclass Correlation Coefficient (ICC). ICC is a descriptive statistic that is used as an assessment for the stability of a quantitative measurement tool, (Miller & Miller, 2004).

The correlation coefficient value is between +1 and -1, where the negative value mean reverse correlation and the positive value mean forward correlation. The accepted value of correlation coefficient depends on the needs of the research itself or the field of study. For example, for calibrating chemistry instrument, the required value is at least 0.98. In addition, for treatment process regression a value of 0.6 or 0.8 is enough to be acceptable. Also for biology research, a value of 0.3 is accepted. But in general, coefficient value if less than 0.3 is poor, between 0.3 and 0.5 is weak, between 0.5 and 0.7 is moderate, more than 0.7 is strong and 1 is perfect, (Kufs, 2010).

Referring to Kines et al. (2011), a correlation coefficient for safety climate questionnaire if above 0.4 is acceptable correlation, and above 0.8 is strong correlation. In general, these values are considered suitable for the safety climate of the industrial sector including power plants.

The following is the way of calculating the correlation coefficient (Miller & Miller, 2004):

$$\bar{x} = (\text{SUM} (x_{n1} + x_{n2})) / 2n \quad (4.10)$$

$$S^2 = (\text{SUM} (x_{n1} - \bar{x})^2 + \text{SUM} (x_{n2} - \bar{x})^2) / 2n \quad (4.11)$$

$$r = (\text{SUM} ((x_{n1} - \bar{x}) (x_{n2} - \bar{x}))) / nS^2 \quad (4.12)$$

Where:

r : correlation coefficient

n : number of objects

x_{n1} : the first rating

x_{n2} : the second rating

The following is an example of calculating the correlation coefficient for five objects and two trials:

n : number of objects

x_{n1} : 2, 3, 2, 5, 1

x_{n2} : 2, 2, 3, 4, 2

$\bar{x} = 26/10 = 2.6$

$S^2 = (9.2 + 3.2) / 10 = 1.24$

$r = 4.2 / (5 \times 1.24) = 0.677$

$r = 0.677$ is considered acceptable correlation value for the safety climate questionnaire according to Kines et al. (2011).

4.6 Defining safety culture

In background section there is a question about safety culture definition, the result of this question is used to propose new definition for safety culture. As mentioned by Mathis and Galloway (2013), that safety culture definition is not fixed but anyone can understand the definition based on available information and facts. So in order to define the safety culture, the answers should be collected and compared with the literature review definitions. In addition, it should be related to the power plant safety. This can be done in coordination of safety department members.

4.7 Conducting safety workshop

Safety workshop was conducted for a group of employees (Al Dur shift workers) followed by re-distribution of the questionnaire to check the effect of the safety workshops on the safety awareness of the employees. The workshop has been done with the coordination of safety department by focusing on the weak points that have been found from the questionnaire analysis. The impact of the safety workshop on the results is reported in section 5.7.

4.8 Seeking solutions for improving safety culture

Based on the findings of the weaknesses, set of suggestions were distributed among the managers (in both sites) with the request of rating the suggestions from 1 to 5 based on the effectively of the suggestion to improve the safety culture, also the participants had a space to write more suggestions. The results will help in determining the best solutions to be applied in order to improve the safety culture.

The distributed form of the suggestions is shown in appendix E. The analysis of suggestions and its effect is giving in section 5.10.

Chapter five

Results and analysis

5.1 Classification of population

5.2 The stability and internal consistency of the questionnaire

5.3 Level of safety climate at Al Ezzel Operation and Maintenance (O&M)
(Both sites)

5.4 Factors that influence the level of safety climate

5.5 Sub-climates at Al Ezzel O&M

5.6 Questionnaire results (results of individual questions)

5.7 Results after conducting safety workshop

5.8 Definition of safety culture based on employees understanding

5.9 Results of the interviews

5.10 Suggested solutions to improve safety culture

Chapter five

Results and analysis

5 Results and analysis

The results of the presented work are presented in this chapter. They include the results of testing the questionnaire as well as the results of conducting the questionnaire and interviews.

5.1 Classification of population

Referring to the background questions, the description of the studied population can be figure out and illustrated.

As mentioned earlier, Al Ezzel O&M includes two sites. The first one is Al Ezzel power plant and the second one is Al Dur power and water production plant. Al Ezzel site has 40% of the participants and Al Dur site has 60% of the participants as shown in figure 5.1. This difference is due to the generating capacity and activity of each site. Al Dur site is larger with more functions, as it is producing water alongside with electric power generation.

Regarding the age, the majority of the populations are in the range of 31-40 years with 58% of population. The range of 41-50 years comes second by 33% of the population. The least is for the range of 20-30 years with 9% only (figure 5.1).

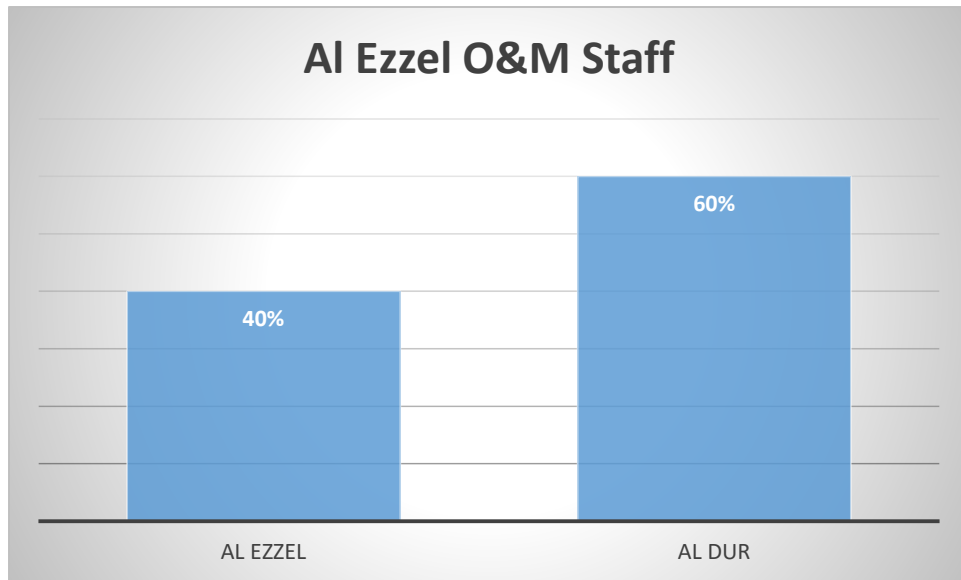


Figure (5.1) The staff of Al Ezzel O&M distribution based on the site location.

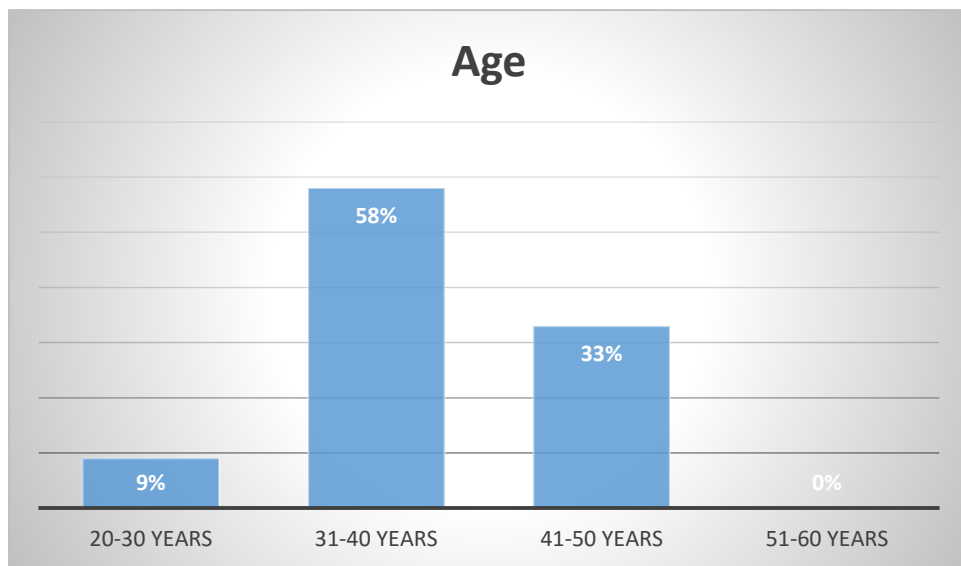


Figure (5.2) The staff of Al Ezzel O&M distribution based on their age.

For the experience within Al Ezzel O&M, (as shown in figure 5.3) 58% of the workers have more than 6 years of experience. 29% of them have 4 to 6 years of experience. 13% have an experience of 1 to 3 years.

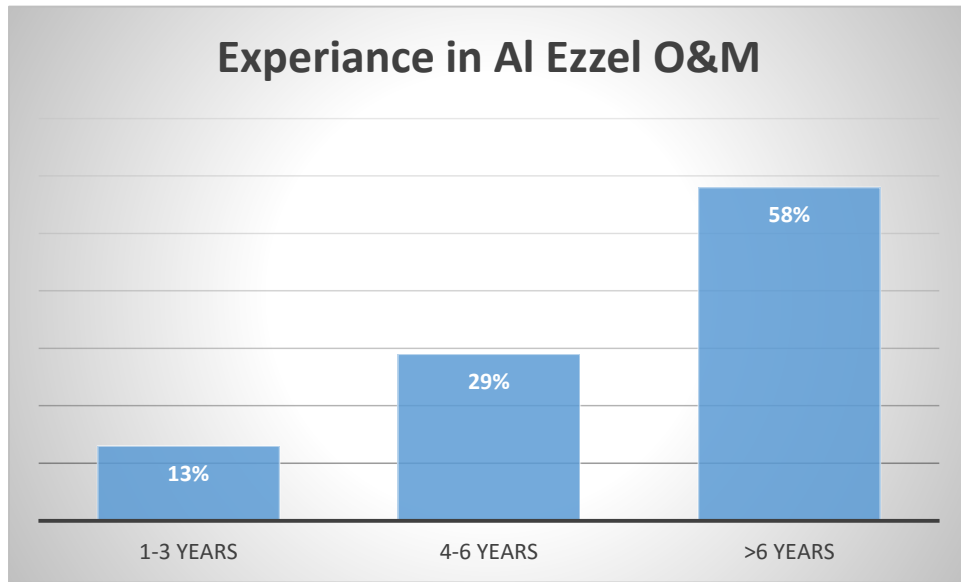


Figure (5.3) The staff of Al Ezzel O&M distribution based on their experience within Al Ezzel O&M.

Also relating to the experience, the experience in current position is 38% of the population has 1 to 3 years of experience in current position. 37% of them have 4 to 6 years and 25% have more than 6 years of experience in current position as shown in figure 5.4.

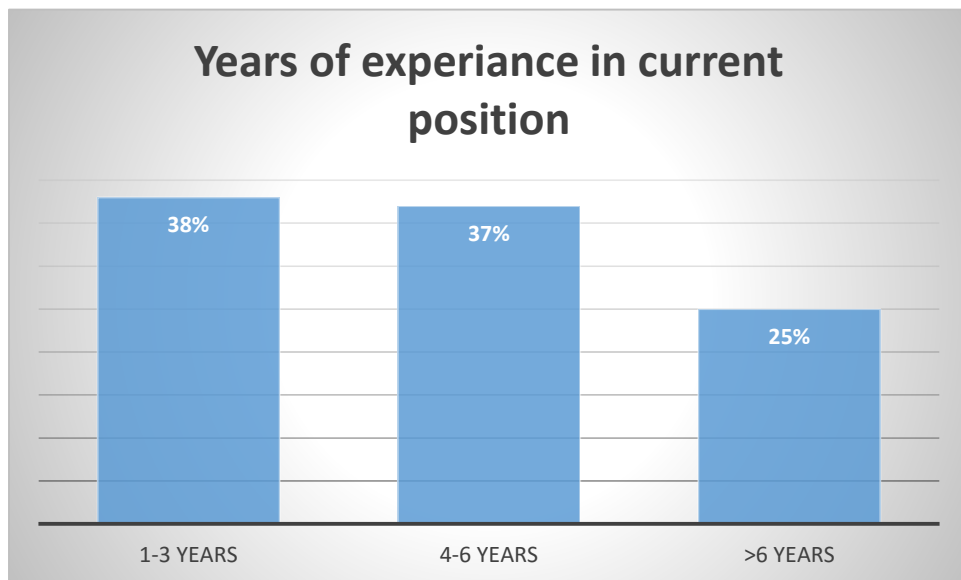


Figure (5.4) The staff of Al Ezzel O&M distribution based on their experience in current position.

Figure 5.5 shows the number of workplaces that the employees worked for. 57% of the employees work in 1 to 2 places. 32% of the employees work in 3 to 4 places and 11% of them work in 4 places.

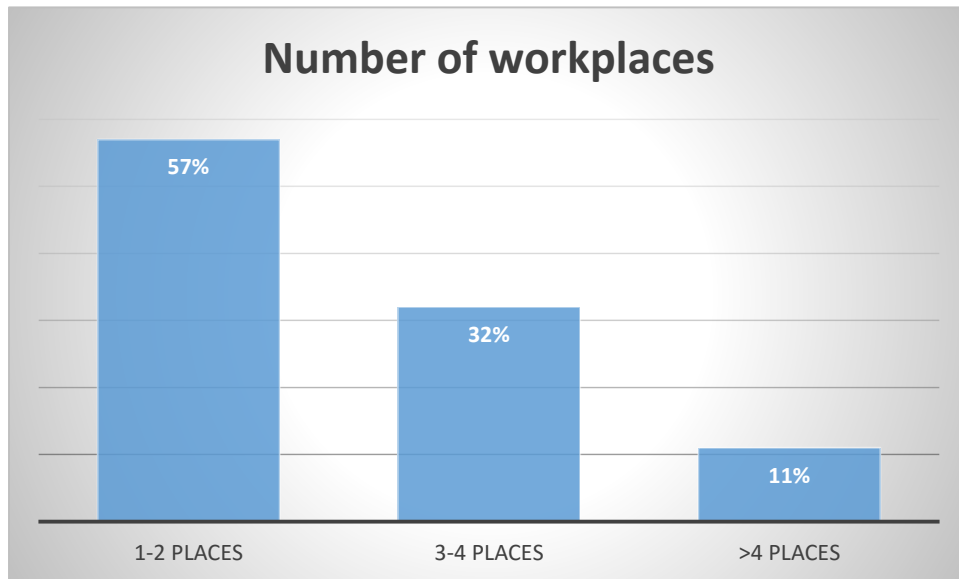


Figure (5.5) The staff of Al Ezzel O&M distribution based on the number of workplaces that they worked for.

Al Ezzel O&M is caring for conducting the safety training. That can be figured out by looking to the number of safety workshops attended by the employee. 50% of the employees attended more than 6 workshops. 29% of the employees have attended between 3 and 4 workshops. 21% attended between 1 and 2 workshops. This result is illustrated in figure 5.6.

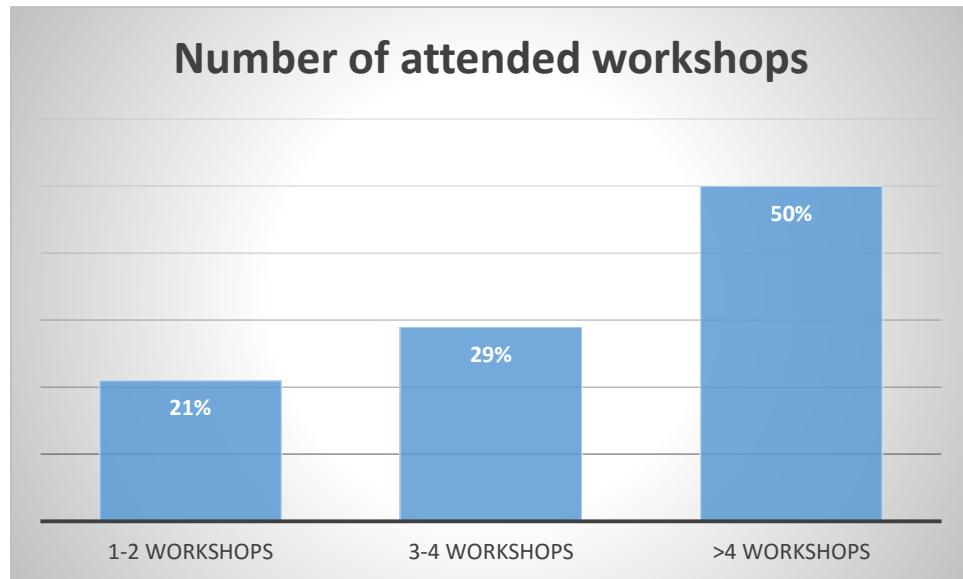


Figure (5.6) The staff of Al Ezzel O&M distribution based on the number safety workshops that attended by the worker.

For groups had been identified within Al Ezzel O&M. Al Ezzel day time workers (16%), Al Ezzel shift workers (21%), Al Dur daytime workers (25%), and Al Dur shift workers (38%). Figure 5.7 shows the four groups and their percentage within the population.

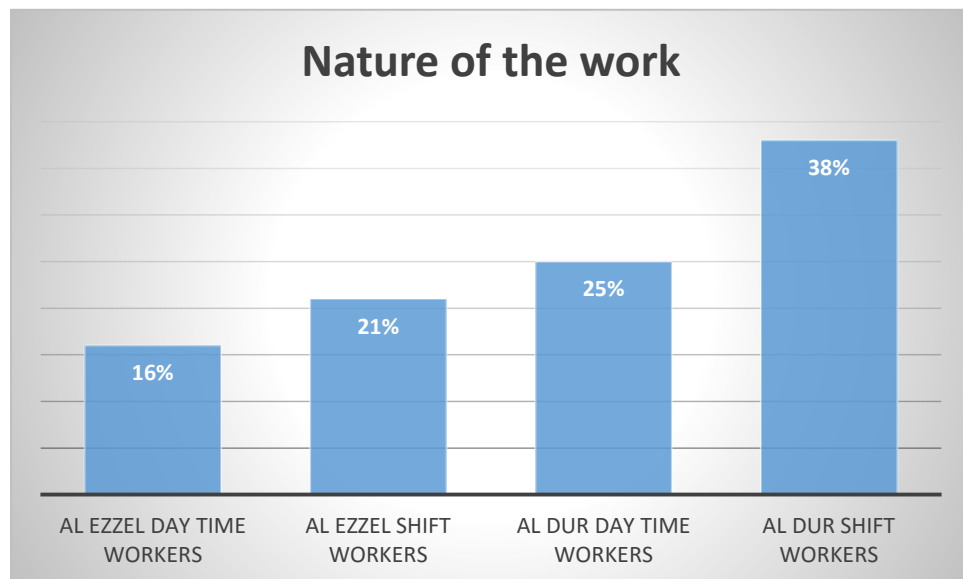


Figure (5.7) The staff of Al Ezzel O&M distribution based on their nature of work.

As shown in figure 5.8, 59% of the employees know what safety culture is. Moreover, 41% of the employees do not know what the safety culture is. This has been indicated by reviewing the question of safety culture definition in the background questions.

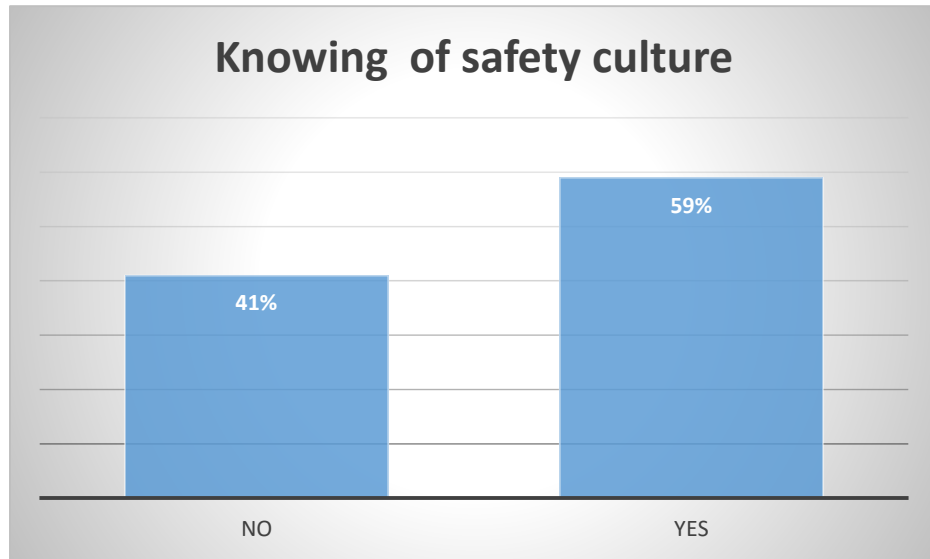


Figure (5.8) The knowledge of the staff about safety culture.

For the qualification of the employees, the majority of the employees are holding B.Sc. degree or equivalent degree with a ratio of 52%. The diploma holders are 38% of the total employees. The high school certificate holders are 9%, while 1% of employees are M.Sc. degree holders which is the least. These results of degrees ratio is shown in figure 5.9.

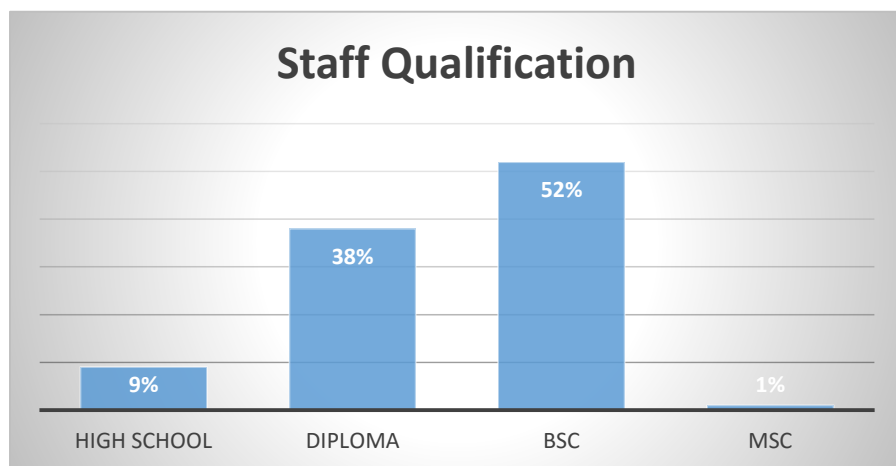


Figure (5.9) The staff of Al Ezzel O&M distribution based on their qualification degree.

The workers of Al Ezzel O&M are 77% of the employees, where the managers/supervisors are 16% and the safety department employees are 7%, as shown in figure 5.10.

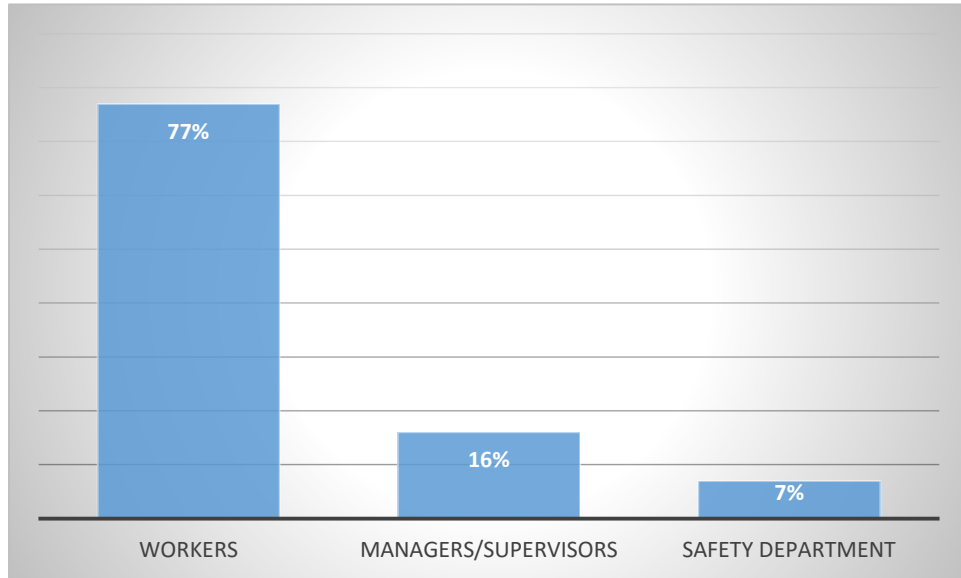


Figure (5.10) The staff of Al Ezzel O&M distribution based on their work.

5.2 The stability and internal consistency of the questionnaire

In order to evaluate the reliability of the questionnaire, two tests have been done. The stability test and internal consistency test.

The stability has been measured by using Interclass Correlation Coefficient (ICC), (Kines et al., 2011). By calculating the correlation coefficient for a sample of participants, it has been found between 0.495 and 0.751, which is considered as acceptable stability, (Kines et al., 2011)

The Cronbach alpha analysis has been applied to test the internal consistency of the results of the present study. It was found that the alpha coefficients for most of the questionnaire dimensions were between 0.65 and 0.81 – except for two dimensions- which is considered acceptable, ideal and reliable,

(Pallant, 2007; George et al., 2003, Gliem et al., 2003). The reliability coefficient is the highest for the safety department, which may be related to the better understanding for safety department toward the safety issues. The results of the internal consistency test are given in table 5.1.

Table (5.1) Cronbach alpha coefficients (r_{α} : reliability coefficient) for each dimension

Classification	Cronbach alpha coefficients (reliability coefficient) for each dimension							
	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Workers	0.80	0.76	0.65	0.58	0.71	0.55	0.69	0.68
Managers/supervisors	0.81	0.72	0.71	0.73	0.66	0.71	0.73	0.72
Safety department	0.80	0.78	0.76	0.77	0.79	0.80	0.75	0.78

DIM = Dimension

5.3 Level of safety climate at Al Ezzel Operation and Maintenance (O&M) (Both sites)

The results of safety climate evaluation at Al Ezzel power plant and Al Dur power and water production plant show that the overall safety climate at Al Ezzel operation and maintenance is above average (in the presented study it is considered that if the mean score above 3 it is positive result). The overall mean score for the employees in both sites is 3.67 on scale of (1 to 5). The mean score for Al Ezzel site is greater than Al Dur site, where in Al Ezzel the mean score is 3.93 and in Al Dur 3.49. The lowest mean score obtained in dimension 4 for Al Dur (2.86). Table 5.2 shows the mean score alongside with the standard deviation of the overall level of safety climate. The mean score for each dimension in both Sites are shown in table 5.3. The result of the T-test analysis shows that there is significant difference between both sites in three dimensions, dimension 1 (Management safety priority and ability), dimension 4 (Workers' safety commitment) and dimension 6 (Peer safety communication learning and trust in safety ability). The same is illustrated in figure 5.11. This variance in safety climate level may be due to

locating of management in Al Ezzel site that gave Al Ezzel preference in adapting the safety rules and enhancing the safety communication and reporting.

Table (5.2) The mean scores and standard deviations of Al Ezzel O&M workers (both sites)

Safety climate analysis results	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Mean value (out of 5)	3.61	3.77	3.81	3.42	3.63	3.51	3.99	3.67
Percentage of mean value out of the full scale	65.3%	69.3%	70%	60.5%	65.8%	62.8%	74.8%	66.8%
Standard Deviation	0.41	0.52	0.4	0.67	0.43	0.54	0.42	0.35

Table (5.3) The variation in the level of safety climate between Al Ezzel and Al Dur workers

Site	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Al Ezzel	40%	3.81	3.93	3.94	4.01	3.73	3.97	4.14	3.93
		70.25%	73.25%	73.5%	75.25%	68.25%	74.25%	78.5%	73.25%
Al Dur	60%	3.53	3.71	3.73	2.86	3.62	3.13	3.88	3.49
		63.25%	67.75%	68.25%	46.5%	65.5%	53.25%	72%	62.25%
P-value		0.035	NS	NS	2.14E-10	NS	1.57E-8	NS	5.9E-05

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

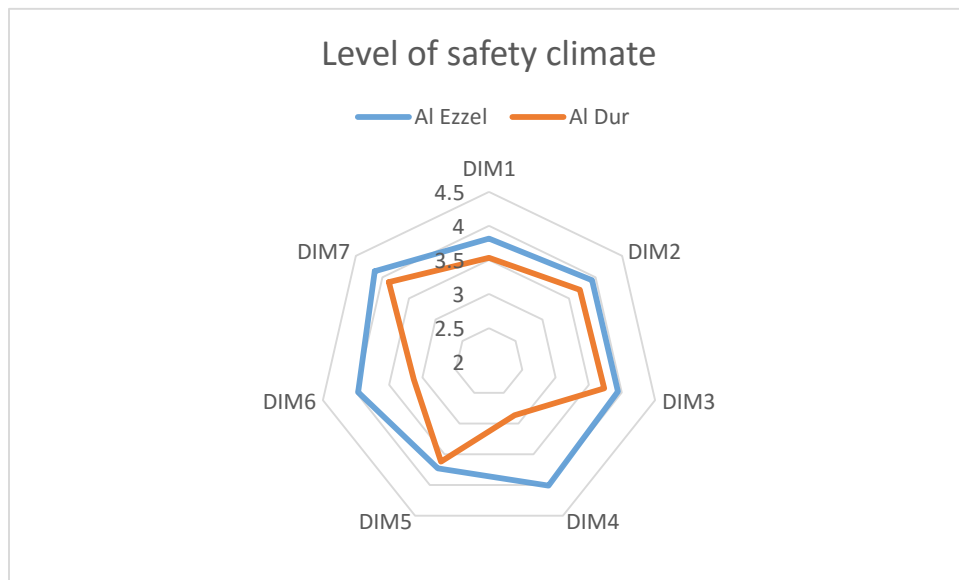


Figure (5.11) The variation in the level of safety climate between Al Ezzel and Al Dur workers as shown in table 5.3

5.4 Factors that influence the level of safety climate

Different factors had been analyzed in order to figure out how it can influence the level of safety climate. The factors as follow:

- Age (table 5.4, figure 5.12)
- Experience in Al Ezzel O&M (table 5.5, figure 5.13)
- Number of workplaces for the employee (table 5.6, figure 5.14)
- Number of attended safety workshops (table 5.7, figure 5.15)
- Knowing of safety culture (table 5.8, figure 5.16)
- Years of experience in current position (table 5.9, figure 5.17)
- Gender

5.4.1 Age

The age of the employees divided into four categories. First category was from 20 to 30 years. Second was from 31 to 40 years. Third was from 41 to 50 years. Last category is from 51 to 60, which no participant recorded in this category.

Table 5.4 and figure 5.12 show the variation in level of safety climate depending on the age of the employees. The results show that the significant difference occurs only between the first category and the second category. The variation is in four dimensions, dimension 1(Management safety priority and ability), dimension 3 (Management safety judgment), dimension 5 (workers' safety priority and risk non-acceptance) and dimension 6 (Peer safety communication learning and trust in safety ability). In general, the first and the third categories have higher level of safety culture than the second category.

Table (5.4) The variation in the level of safety climate depending on the age of the workers at Al Ezzel O&M.

Age	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
1. 20-30 years	9%	4.33	4.14	4.25	4.58	4.29	4.19	4	4.25
		83.25%	78.5%	81.25%	89.5%	82.25%	79.75%	75%	81.25%
2. 31-40 years	58%	3.78	3.88	3.83	3.92	3.67	3.9	4.06	3.86
		69.5%	72%	70.75%	73%	66.75%	72.5%	76.5%	71.5%
3. 41-50 years	33%	4.1	4.25	4.04	4.15	4.04	3.98	4.36	4.13
		77.5%	81.25%	76%	78.75%	76%	74.5%	84%	78.25%
4. 51-60 years	0%	-	-	-	-	-	-	-	
P-value: 1-2		0.024	NS	0.027	NS	0.04	0.044	NS	NS
P-value: 1-3		NS	NS	NS	NS	NS	NS	NS	NS
P-value: 2-3		NS	NS	NS	NS	NS	NS	NS	NS

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

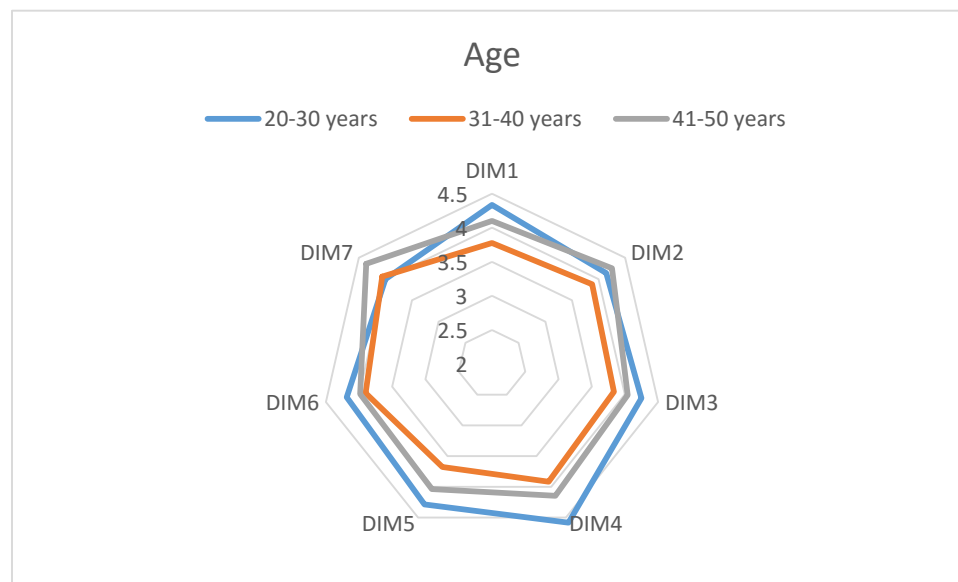


Figure (5.12) The variation in the level of safety climate depending on the age of the workers at Al Ezzel O&M as shown in table 5.4.

5.4.2 Experience in Al Ezzel O&M

For the experience in Al Ezzel O&M, it is divided into three categories. First category is from 1 to 3 years. Second, is from 4 to 6 years. And the last category, is more than 6 years.

For the experience in Al Ezzel O&M, there is only one significant difference that is between first and third category in dimension 7 (workers' trust in efficiency of safety system). This indicates that the experience in Al Ezzel has a minor effect on the level of safety climate. The results are shown in table 5.5 and figure 5.13. One reason for this difference in dimension seven, is that the trust increasing with the time between the workers and the management.

Table (5.5) The variation in the level of safety climate depending on the experience of the workers in Al Ezzel O&M.

Exp. in Al Ezzel O&M	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
1. 1-3yrs	13%	4.07	3.95	4.06	4.11	3.86	3.96	3.81	3.97
		76.75%	73.75%	76.5%	77.75%	71.5%	74%	70.25%	74.25%
2. 4-6 yrs.	29%	3.73	4.06	3.93	4.05	3.69	4.05	4.16	3.95
		68.25%	76.5%	73.25%	76.25%	67.25%	76.25%	79%	73.75%
3. > 6yrs	58%	4	4.02	3.92	4.04	3.92	3.9	4.22	4
		75%	75.5%	73%	76%	73%	72.5%	80.5%	75%
P-value: 1-2		NS	NS	NS	NS	NS	NS	0.024	NS
P-value: 1-3		NS	NS	NS	NS	NS	NS	NS	NS
P-value: 2-3		NS	NS	NS	NS	NS	NS	NS	NS

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

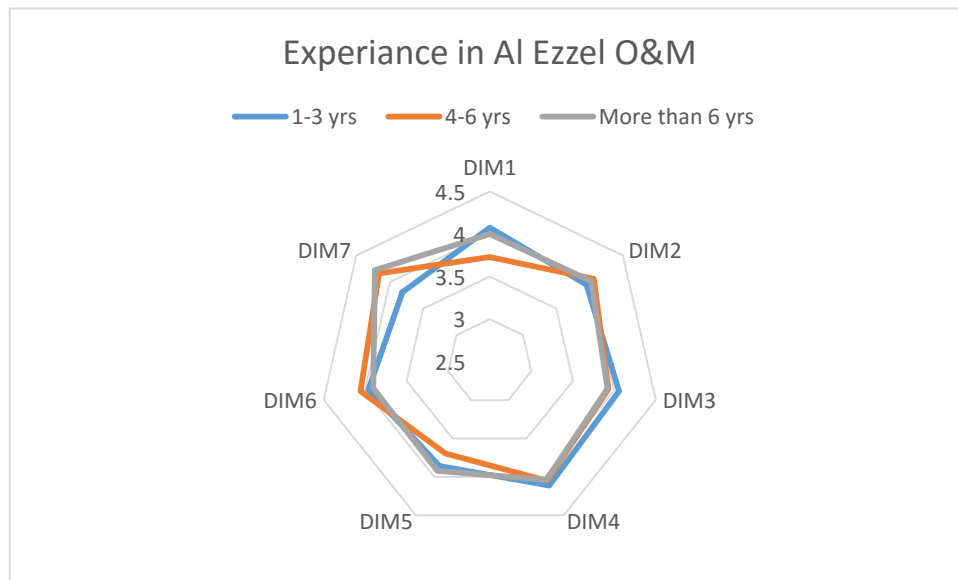


Figure (5.13) The variation in the level of safety climate depending on the experience of the workers in Al Ezzel O&M as shown in table 5.5.

5.4.3 Number of workplaces for the employee

The number of workplaces for each employee is divided, into three categories. First category is from 1 to 2 workplaces. Second, is from 3 to 4 workplaces. And the last category is for more than 4 workplaces.

The analysis of the number of workplaces that employee had before showed some significant difference between first and third categories and between second and third categories. The difference between first and third categories are in dimension 4 (Workers safety commitment), dimension 5 (workers' safety priority and risk non-acceptance) and dimension 7 (workers' trust in efficiency of safety system). The difference between second and third categories is in dimensions 5 and 7. The results showed that the more workplaces will have positive impact on the level of safety climate. The results are shown on table 5.6 and figure 4.14. Probable reason for this difference is that the workers with more workplaces have more experience in different environments and different safety systems, which lead to higher safety awareness.

Table (5.6) The variation in the level of safety climate depending on the workplaces of the workers before joining Al Ezzel O&M.

No. of workplaces	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
1. 1-2	57%	3.89	3.91	3.86	3.94	3.79	3.96	4.1	3.92
		72.25%	72.75%	71.5%	73.5%	69.75%	74%	77.5%	73%
2. 3-4	32%	3.9	4.12	4	4.17	3.79	3.94	4.12	4.01
		72.5%	78%	75%	79.25%	69.75%	73.5%	78%	75.25%
3. > 4	11%	4.33	4.43	4.25	4.33	4.5	4	4.64	4.35
		83.25%	85.75%	81.25%	83.25%	87.5%	75%	91%	83.75%
P-value: 1-2		NS	NS	NS	NS	NS	NS	NS	NS
P-value: 1-3		NS	NS	NS	0.012	0.0008	NS	0.004	0.004
P-value: 2-3		NS	NS	NS	NS	0.009	NS	0.013	0.048

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

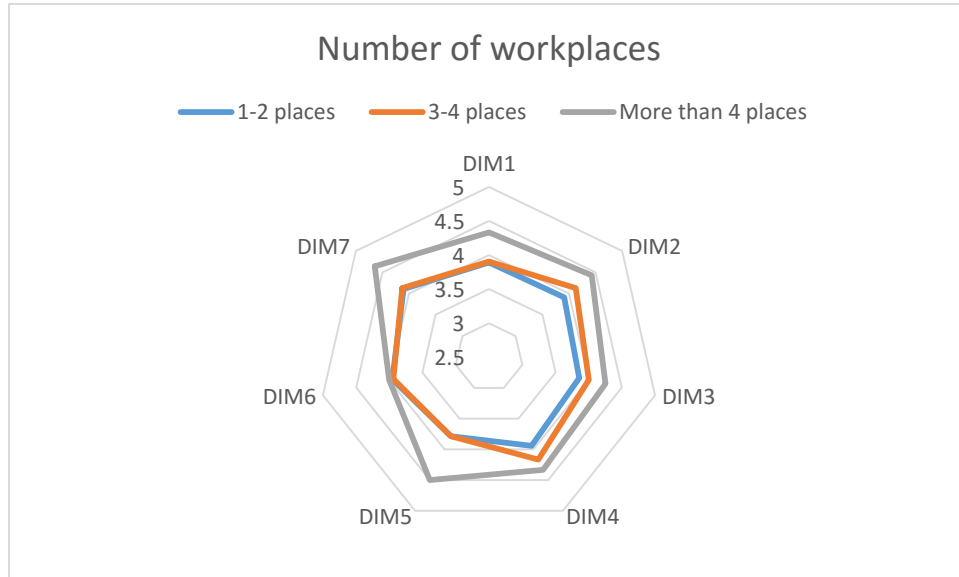


Figure (5.14) The variation in the level of safety climate depending on the workplaces of the workers before joining Al Ezzel O&M as shown in table 5.6.

5.4.4 Number of attended safety workshops

The number of attended safety workshops by the employee is divided into three categories. First category is for 1 to 2 safety workshops. Second, is for 3 to 4 safety workshops. And the last category is for more than 4 safety workshops.

Table 5.7 and figure 5.15 show the variation in the level of safety climate depending on the number of safety workshops attended by the employee. The results showed low significant difference between first and second categories, which only in dimension 7 (workers' trust in efficiency of safety system). In addition, it showed low significant difference between first and third categories, which are in dimension 2 (management safety empowerment) and dimension 7. There is no significant difference between second and third categories, which indicate that conducting more than six workshops will have low effect on the improvement in the level of the safety

climate. In general, more safety workshops will lead to better level in the safety climate.

Table (5.7) The variation in the level of safety climate depending on the safety workshop attended by the worker.

No. of workshops	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
1. 1-2	21%	3.64	3.86	3.73	4.03	3.49	3.82	3.89	3.78
		66%	71.5%	68.25%	75.75%	62.25%	70.5%	72.25%	69.5%
2. 3-4	29%	3.92	3.65	4	4.19	3.92	3.91	4.16	3.96
		73%	66.25%	75%	79.75%	73%	72.75%	79%	74%
3. > 4	50%	4.06	4.31	3.99	3.97	3.95	4.03	4.26	4.08
		76.5%	82.75%	74.75%	74.25%	73.75%	75.75%	81.5%	77%
P-value: 1-2		NS	NS	NS	NS	NS	NS	0.036	NS
P-value: 1-3		NS	0.015	NS	NS	NS	NS	0.0499	NS
P-value: 2-3		NS	NS	NS	NS	NS	NS	NS	NS

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test



Figure (5.15) The variation in the level of safety climate depending on the safety workshop attended by the worker as shown in table 5.7.

5.4.5 Knowing of safety culture

For the knowledge of the safety culture, there is no significant difference, but in general the employees who know the safety culture, they score higher level of safety climate in six dimensions, except for dimension 4 (workers

safety commitment), where they scored less. However, it was also not a significant difference in this dimension. Table 5.8 and figure 5.16 show the results of knowing of the safety culture analysis. Possible reason behind having higher score for the group that know what the safety culture is, is this group has more safety awareness and may involve more in the safety activities. No clear reason for the lower score in dimension four.

Table (5.8) The variation in the level of safety climate depending knowledge of the safety culture among Al Ezzel O&M workers.

Knowing of safety culture	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
No	41%	3.72	3.71	3.85	4.12	3.71	3.95	4.04	3.87
		68%	67.75%	71.25%	78%	67.75%	73.75%	76%	71.75%
Yes	59%	4.08	4.24	4	4	3.94	3.96	4.23	4.05
		77%	81%	75%	75%	73.5%	74%	80.75%	76.25%
P-value		NS	NS	NS	NS	NS	NS	NS	NS

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

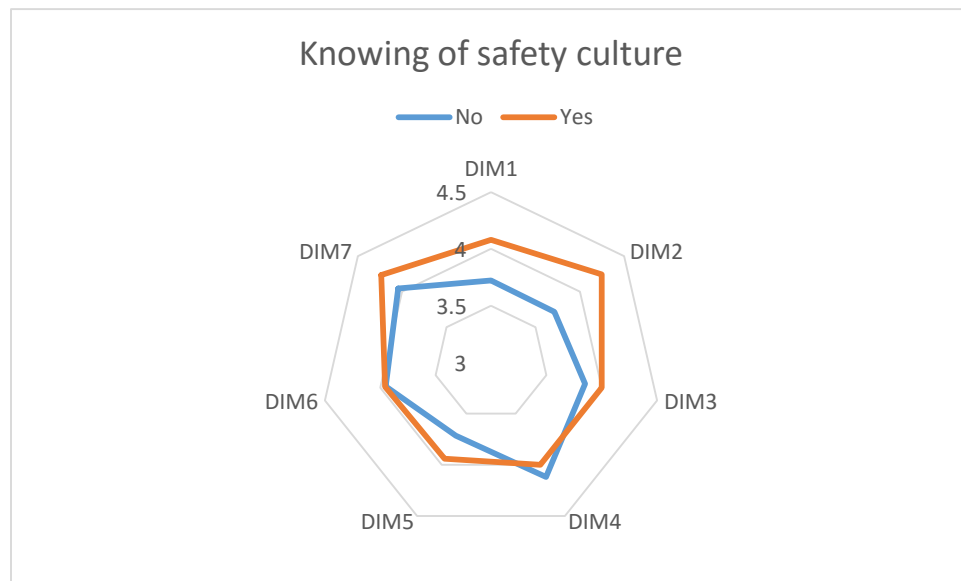


Figure (5.16) The variation in the level of safety climate depending knowledge of the safety culture as shown in table 5.8.

5.4.6 Years of experience in current position

The years of experience in current position, are divided into three categories. First category is from 1 to 3 years. Second, it is from 4 to 6 years. And the last category is for more than 6 years of experience in current position.

For the years of experience in current position, no significant difference has been found between the different categories but in general the lowest experience in current position showed the lowest safety climate level. While the second category showed the highest safety climate level and the third category was in the middle. Table 5.9 and figure 5.16 show the variation in the level of safety climate of the related issue. This can indicate a decrement in safety climate level after long experience in the same position.

Table (5.9) The variation in the level of safety climate depending on the experience in current position for Al Ezzel workers.

Exp. in current position	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
1.1-3	38%	3.93	3.9	3.93	3.94	3.84	3.93	4.06	3.93
		73.25%	72.5%	73.25%	73.5%	71%	73.25%	76.5%	73.25%
2. 4-6	37%	4.08	4.22	4.12	4.21	3.86	4.1	4.22	4.12%
		77%	80.5%	78%	80.25%	71.5%	77.5%	80.5%	78%
3. >6	25%	4.06	3.9	3.97	4.03	3.83	3.77	4.19	3.96
		76.5%	72.5%	74.25%	75.75%	70.75%	69.25%	79.75%	74%
P-value: 1-2		NS	NS	NS	NS	NS	NS	NS	NS
P-value: 1-3		NS	NS	NS	NS	NS	NS	NS	NS
P-value: 2-3		NS	NS	NS	NS	NS	NS	NS	NS

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

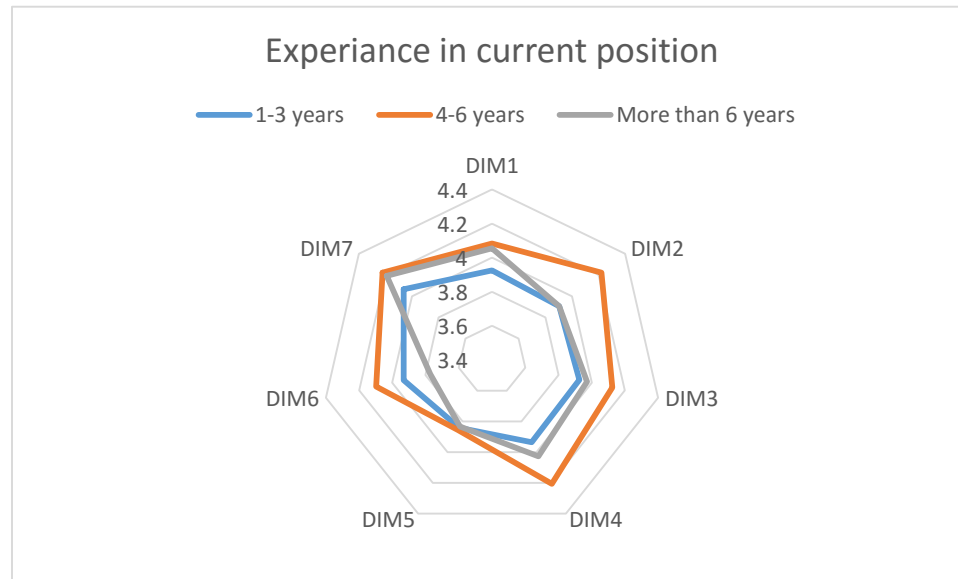


Figure (5.17) The variation in the level of safety climate depending on the experience in current position for Al Ezzel workers as shown in table 5.9.

5.4.7 Gender

More than 96% of the employees are males, and the females are in positions not related to the field under study, so this test is not applicable to the presented study.

5.5 Sub-climates at Al Ezzel O&M

When investigating potential sub-climates at Al Ezzel O&M, the variation has been studied between:

- Shift and daytime workers at Al Ezzel site (table 5.10, figure5.18)
- Shift and daytime workers at Al Dur site (table 5.11, figure5.19)
- Shift workers at Al Ezzel and shift workers at Al Dur (table 5.12, figure5.20)
- Daytime workers at Al Ezzel and Daytime workers at Al Dur (table 5.13, figure5.21)
- Workers and supervisors/managers at Al Ezzel O&M (table 5.14, figure5.22)

- Al Ezzel O&M workers and safety department employees (table 5.15, figure5.23)

5.5.1 Shift and daytime workers at Al Ezzel site

Table 5.10 and figure 5.18 show that daytime workers have more safety climate level (4.07) than shift workers at Al-Ezzel site (3.82), but not significantly high difference, the only significant difference is in dimension 1 (Management safety priority and ability) which indicate no sub-climate within Al Ezzel power plant. One reason behind this result is that the shift workers has less contact with the management and the safety activities are conducted in daytime.

Table (5.10) The variation in the level of safety climate within Al Ezzel power plant, between shift workers and daytime workers.

Al Ezzel	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Day time workers	43%	4.06	4.23	4.06	4.04	3.89	3.98	4.29	4.07
		76.5%	80.75%	76.5%	76%	72.25%	74.5%	82.25%	76.75%
Shift workers	57%	3.64	3.71	3.85	3.98	3.61	3.95	4.04	3.82
		66%	67.75%	71.25%	74.5%	65.25%	73.75%	76%	70.5%
P-value		0.029	NS	NS	NS	NS	NS	NS	NS

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

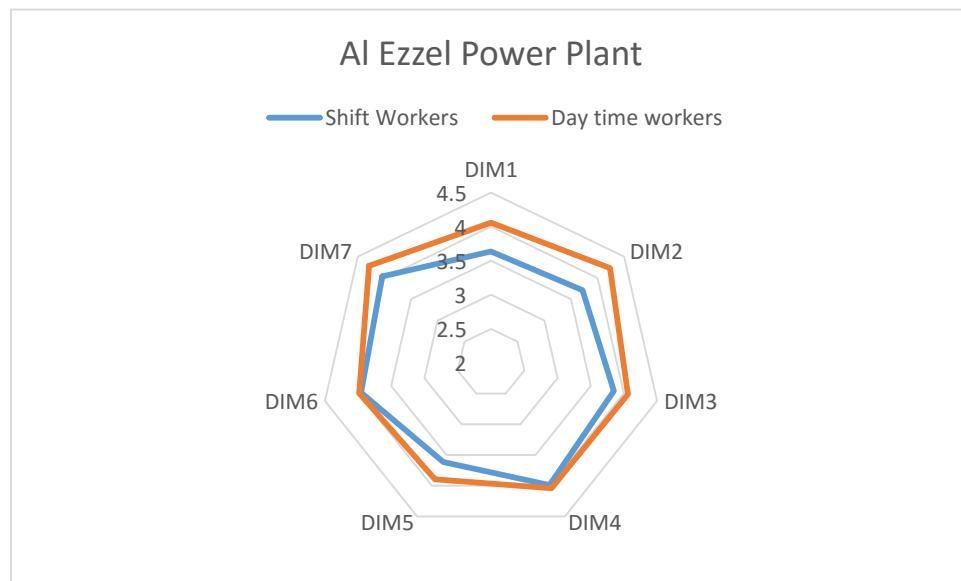


Figure (5.18) The variation in the level of safety climate within Al Ezzel power plant, between shift workers and daytime workers as shown in table 5.10.

5.5.2 Shift and daytime workers at Al Dur site

When comparing the level of safety climate between shift workers (3.37) and daytime workers (3.64) at Al Dur power and water production plant, significant difference has been found in three dimensions. Dimension 1 (Management safety priority and ability), dimension 2 (Management safety empowerment) and dimension 6 (Peer safety communication learning and trust in safety ability). Table 5.11 and figure 5.19 show that daytime workers have higher level of safety climate than shift workers within Al Dur Shift workers may scored less because their team is large compared to the daytime workers, which reduce the effectiveness of communications.

Table (5.11) The variation in the level of safety climate within Al Dur power and water production plant, between shift workers and daytime workers.

Al Dur	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Day time workers	37.5%	3.84	3.91	3.81	2.83	3.75	3.39	4	3.64
		71%	72.75%	70.25%	45.75%	68.75%	59.75%	75%	66%
Shift workers	62.5%	3.28	3.54	3.67	2.89	3.51	2.92	3.79	3.37
		57%	63.5%	66.75%	47.25%	62.75%	48%	69.75%	59.25%
P-value		0.0001	0.01	NS	NS	NS	.003	NS	0.000134

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

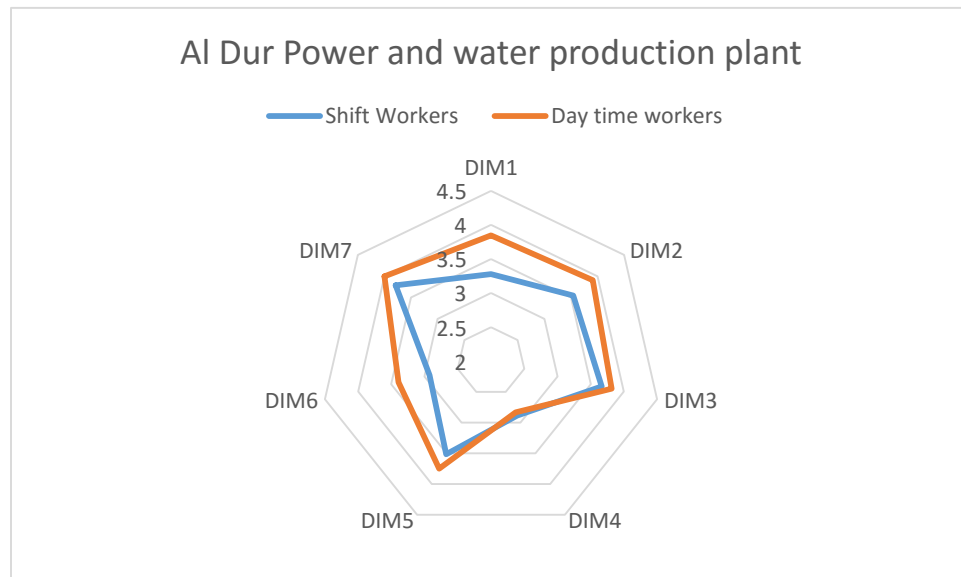


Figure (5.19) The variation in the level of safety climate within Al Dur power and water production plant, between shift workers and daytime workers as shown in table 5.11.

5.5.3 Shift workers at Al Ezzel and shift workers at Al Dur

When comparing the level of safety climate of the shift workers in both Al Ezzel (3.82) and Al Dur (3.37), significant difference has been found in four dimensions. Dimension 1 (Management safety priority and ability), dimension 4 (Workers' safety commitment), dimension 6 (Peer safety communication learning and trust in safety ability) and dimension 7 (Workers' trust in efficiency of safety systems). Table 5.12 and figure 5.20 show that the shift workers for Al Ezzel has higher level of safety climate than the shift workers of Al Dur which related to the results of the overall safety climate between Al Ezzel and Al Dur.

Table (5.12) The variation in the level of safety climate between the shift workers at Al Ezzel O&M.

Site	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Al Ezzel	33.3%	3.67	3.71	3.84	3.98	3.61	3.95	4.04	3.82
		66.75%	67.75%	71%	74.5%	65.25%	73.75%	76%	70.5%
Al Dur	66.6%	3.28	3.54	3.67	2.89	3.51	2.92	3.79	3.37
		57%	63.5%	66.75%	47.25%	62.75%	48%	69.75%	59.25%
P-value		0.01	NS	NS	4.4E-8	NS	7.37E-8	0.032	1.12E-05

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

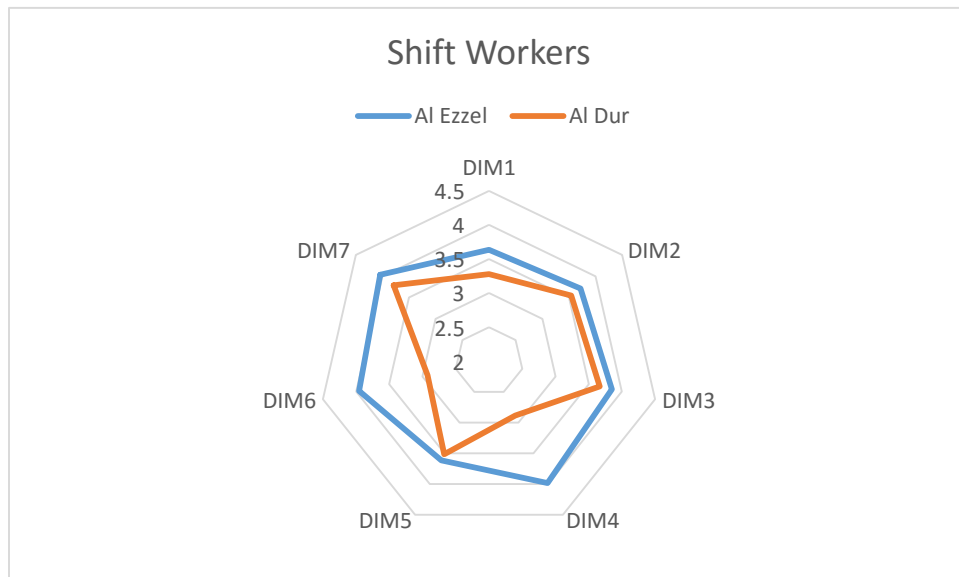


Figure (5.20) The variation in the level of safety climate between the shift workers at Al Ezzel O&M as shown in table 5.12.

5.5.4 Daytime workers at Al Ezzel and Daytime workers at Al Dur

When comparing the level of safety climate of the daytime workers in both Al Ezzel (4.07) and Al Dur (3.64), significant difference has been found in two dimensions, Dimension 4 (Workers' safety commitment) and dimension 6 (Peer safety communication learning and trust in safety ability). The results of Table 5.13 and figure 5.21 show that the daytime workers for Al Ezzel have higher level of safety climate than that of the daytime workers of Al Dur. This is similar to the results of the overall safety climate between Al Ezzel and Al Dur.

Table (5.13) The variation in the level of safety climate between the daytime workers at Al Ezzel O&M.

Site	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Al Ezzel	41%	4.06	4.23	4.06	4.04	3.89	3.98	4.28	4.07
		76.5%	80.75%	76.5%	76%	72.25%	74.5%	82%	76.75%
Al Dur	59%	3.85	3.91	3.81	2.83	3.75	3.39	4	3.62
		71.25%	72.75%	70.25%	45.75%	68.75%	59.75%	75%	66%
P-value		NS	NS	NS	0.0005	NS	NS	0.006	0.0375

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

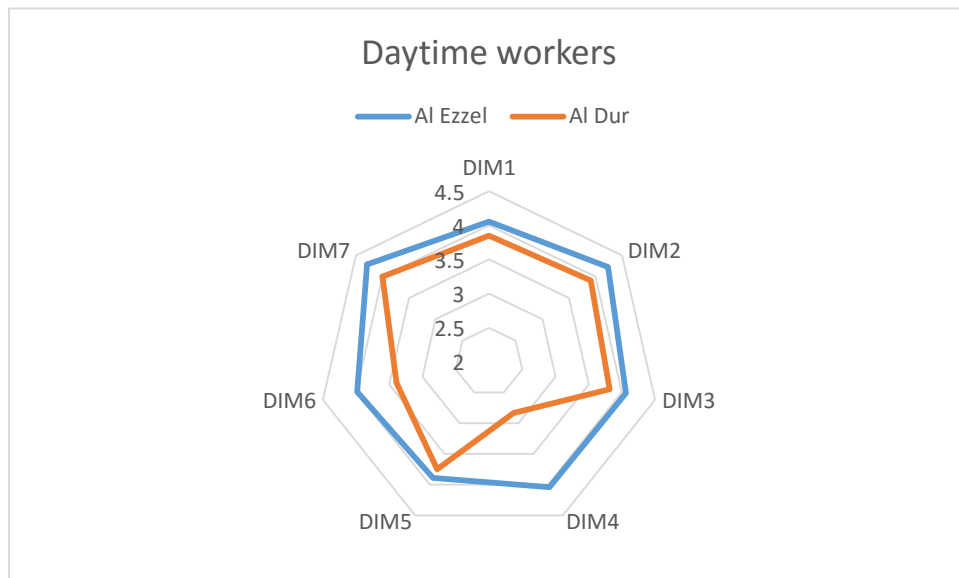


Figure (5.21) The variation in the level of safety climate between the daytime workers at Al Ezzel O&M as shown in table 5.13.

5.5.5 Workers and supervisors/managers at Al Ezzel O&M

For the comparison between the workers (3.67) and managers/supervisors (4.13) at Al Ezzel O&M, significance difference has been found in three dimensions, dimension 1 (Management safety priority and ability), dimension 2 (Management safety empowerment) and dimension 5 (Workers' safety priority and risk non-acceptance). Table 5.14 and figure 5.22 show that the managers/supervisors have higher level of safety climate. A possible reason for this result is that the safety issues discussed between managers and workers are not communicated effectively to the workers.

Table (5.14) The variation in the level of safety climate between the workers and the managers/supervisors at Al Ezzel O&M.

Classification	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Workers	83%	3.61	3.77	3.81	3.42	3.63	3.51	3.99	3.67
		65.3%	69.3%	70%	60.5%	65.8%	62.8%	74.8%	66.8%
Managers/ Supervisors	17%	4.32	4.27	3.92	4.13	4.26	3.88	4.16	4.13
		83%	81.75%	73%	78.25%	81.5%	72%	79%	78.25%
P-value		0.0002	0.048	NS	NS	0.002	NS	NS	0.0088

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

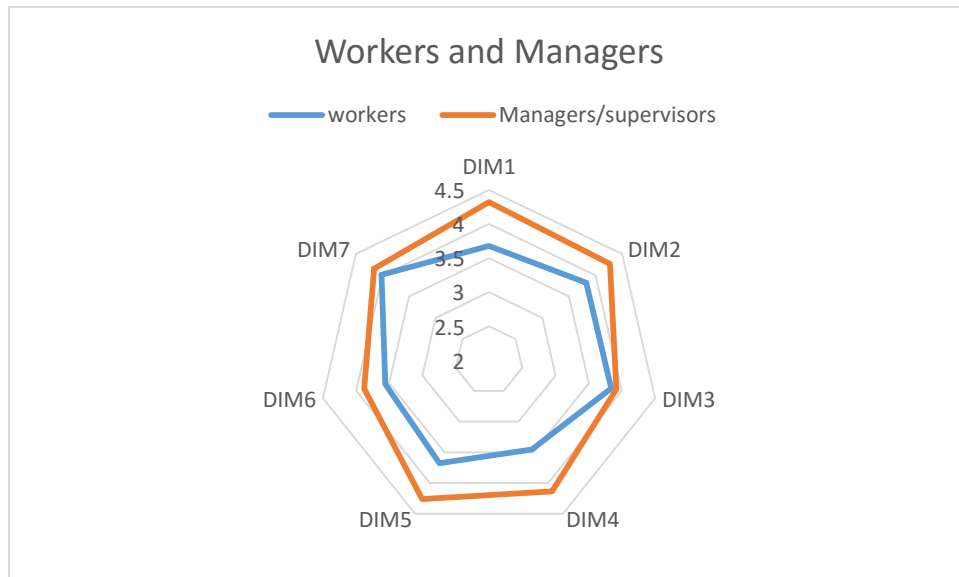


Figure (5.22) The variation in the level of safety climate between the workers and the managers/supervisors at Al Ezzel O&M as shown in table 5.14.

5.5.6 Al Ezzel O&M workers and safety department employees

Compression applied between the workers of Al Ezzel O&M (3.67) and the safety department employees (4) in order to find if there is any difference between the two groups. Table 5.15 and figure 5.23 shows that there is significant difference in dimension 1 (Management safety priority and ability), dimension 4 (Workers' safety commitment) and dimension 5 (Workers' safety priority and risk non-acceptance). A possible reason for this result is that the safety issues discussed between managers and workers are not communicated effectively to the workers.

Table (5.15) The variation in the level of safety climate between the workers and the Safety department employees.

Classification	%	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Workers	92%	3.61	3.77	3.81	3.42	3.63	3.51	3.99	3.67
		65.3%	69.3%	70%	60.5%	65.8%	62.8%	74.8%	66.8%
Safety Dpt.	8%	4.19	4.24	3.9	3.98	4	3.67	4.02	4
		79.75%	81%	72.5%	74.5%	75%	66.75%	75.5%	75%
P-value		0.006	NS	NS	0.006	0.002	NS	NS	0.037

DIM= Dimension, NS= Non-Significant, %= percentage of participants, P-value= result of the T-Test

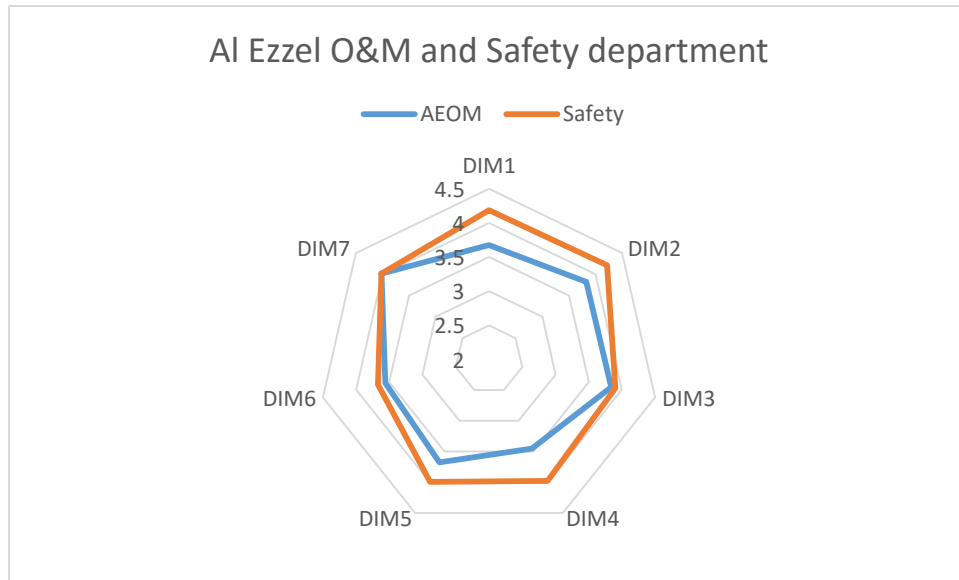


Figure (5.23) The variation in the level of safety climate between the workers and the Safety department employees as shown in table 5.15.

5.6 Questionnaire results (results of individual questions)

By analyzing the questions results (mean value), the low score questions will be detected in order to compare it with the results of the dimensions, this will help in determining the exact reason behind any weaknesses. The results include the questions mean value of Al Ezzel site daytime workers (figure 5.24), Al Ezzel site shift workers (figure 5.25), Al Dur site daytime workers (figure 5.26) and Al Dur site shift workers (figure 5.27).

For Al Ezzel daytime workers, the mean value of three questions are below score of 3 (50% of the scale) as shown in figure 5.24, which are questions 3 (Management ignore any careless behavior in regard with safety), 26 (Avoiding tackling the discovered risks is common behavior in the workplace) and 41 (I have been shown how to do my job safely).

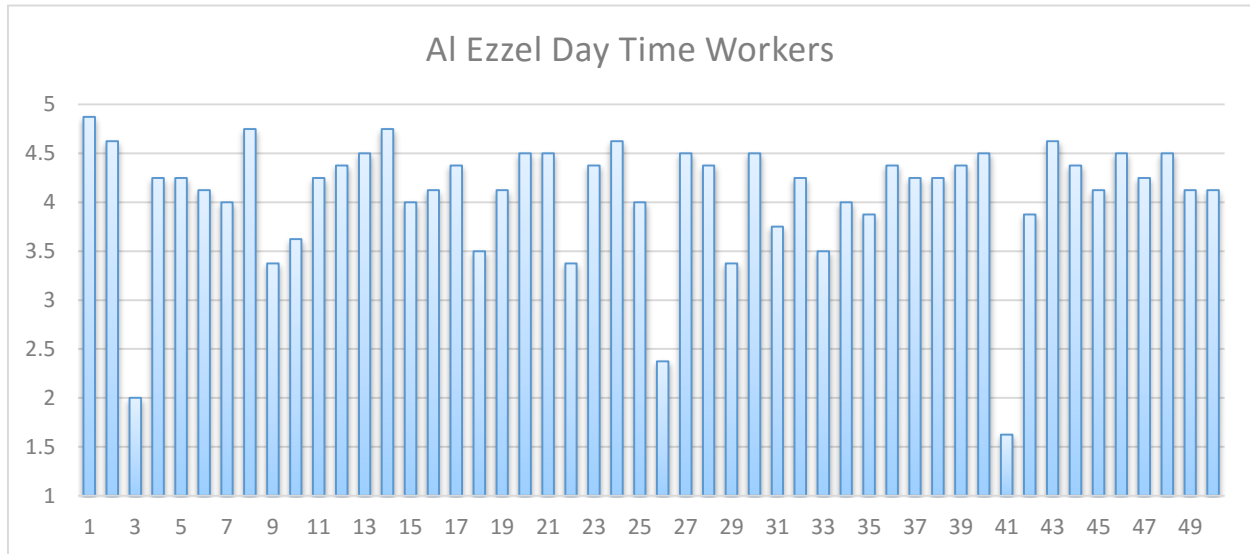


Figure (5.24) The mean value of all questionnaire questions for Al Ezzel daytime workers.

For Al Ezzel shift workers, the results are shown in figure 5.25. The questions below score of 3 are two only which are questions 3 (Management ignore any careless behavior in regard with safety) and 41 (I have been shown how to do my job safely) which indicate some similarities with Al Ezzel daytime workers results. Al Dur daytime workers results show four question with score less than 3 as shown in figure 5.26. Those questions are 3 (Management ignore any careless behavior in regard with safety), 18 (Fear of sanctions from management discourages employees here from report near-miss accidents), 26 (Avoiding tackling the discovered risks is common behavior in the workplace) and 41 (I have been shown how to do my job safely).

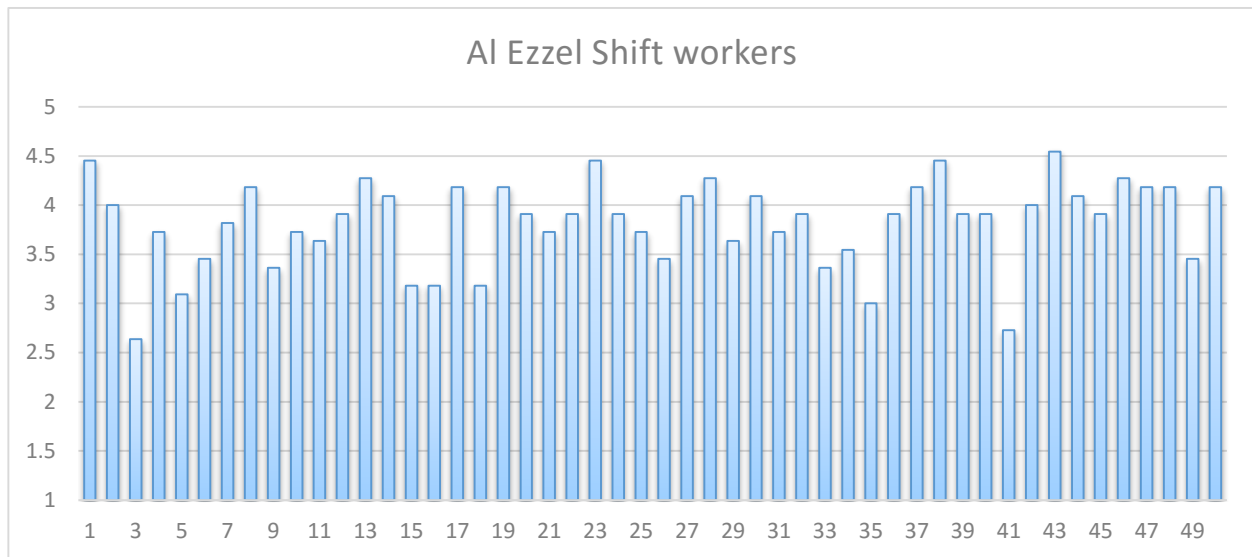


Figure (5.25) The mean value of all questionnaire questions for Al Ezzel shift workers.

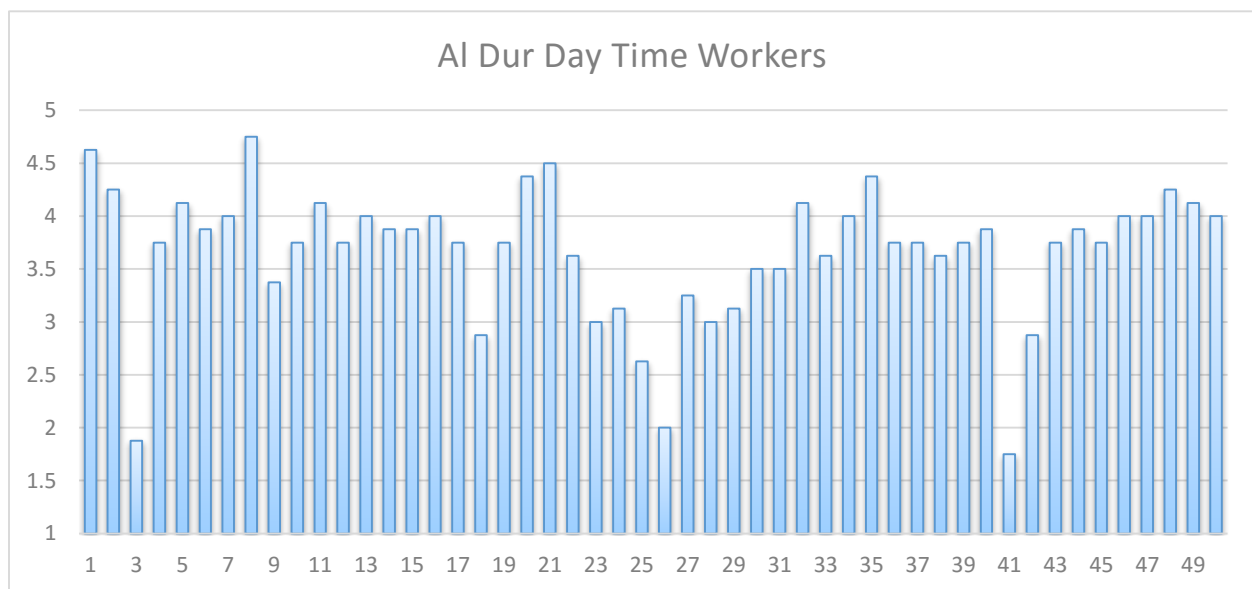


Figure (5.26) The mean value of all questionnaire questions for Al Dur daytime workers.

Finally, the results of Al Dur shift workers indicate thirteen question with mean value scored less than 3 as shown in figure 5.27. Those questions are 3 (Management ignore any careless behavior in regard with safety), 4 (Management places safety before production), 6 (We who work here have confidence in the management's ability to deal with safety), 11 (Management take in consideration the employees opinions in the decisions

that affect their safety), 16 (Safety and health activities are limited to certain people in the plant), 18 (Fear of sanctions from management discourages employees here from report near-miss accidents), 24 (We who work here take joint responsibility to ensure that the workplace is always kept tidy), 25 (On my site we have defined safety improvement objectives), 26 (Avoiding tackling the discovered risks is common behavior in the workplace), 27 (My colleagues and I help each other work safely), 33 (We who work here never accept risk taking even if the work schedule is tight), 34 (Safety specific jobs always get done), 38 (Safety issues are included in communication meeting), 41 (I have been shown how to do my job safely) and 43 (We who work here can talk freely and openly about safety).

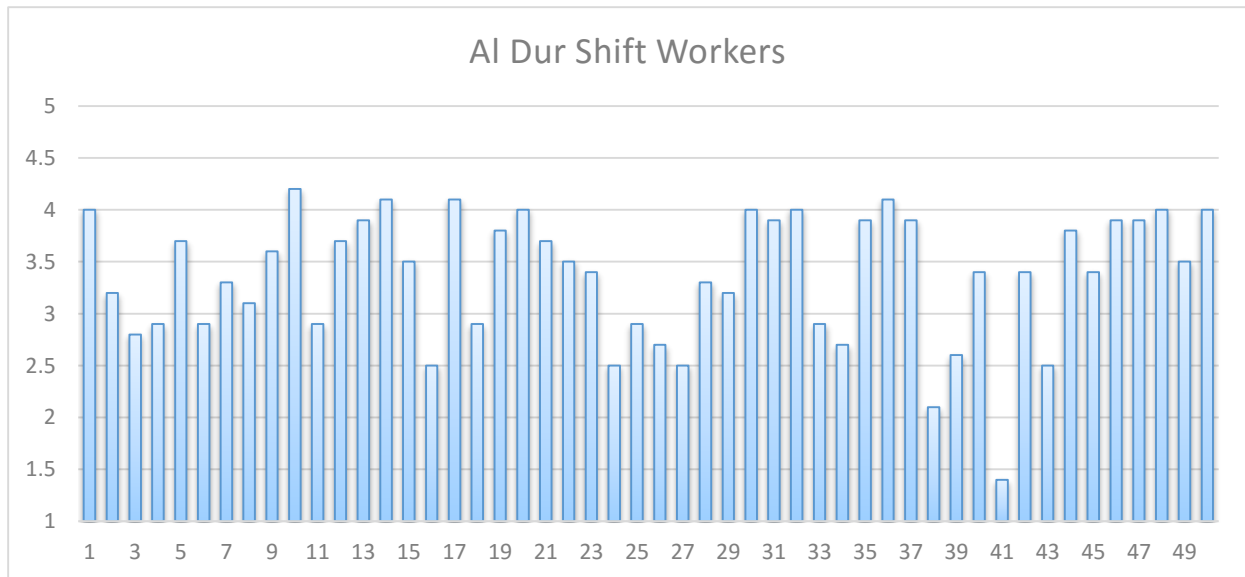


Figure (5.27) The mean value of all questionnaire questions for Al Dur shift workers.

5.7 Results after conducting safety workshop

After collecting the questionnaire, a safety workshop was conducted by coordination with the head of HSE department for the daytime workers of Al Dur power and water production plant as a sample to measure the effect of

the safety workshop in enhancing the level of safety climate in short period. The results showed slight increase in the level of safety climate in all dimension with significant difference in dimension 4 (Workers' safety commitment). Table 5.16 shows the results of the mean score and standard deviations before and after the conducting of the safety workshop. Table 5.17 and figure 5.28 show the results of the analysis.

Table (5.16) The mean scores and standard deviations of Al Dur daytime workers before and after conducting the safety workshop

Measurement	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7	Overall
Mean value before	3.85	3.91	3.81	2.83	3.75	3.39	4	3.65
Standard Deviation before	0.229	0.247	0.412	0.22	0.274	0.296	0.044	0.08
Mean value after	3.88	3.93	3.9	3.17	3.84	3.41	4.04	3.74
Standard Deviation After	0.28	0.247	0.353	0.264	0.271	0.298	0.461	0.121
Difference in mean value	0.278	0.018	.083	0.333	0.089	0.016	0.036	0.086
Percentage of the improvement	0.75%	0.5%	2.25%	8.5%	2.25%	0.5%	1%	0.75%

Table (5.17) The variation in the level of safety climate before and after conducting safety workshop for Al Dur daytime workers.

Al Dur daytime workers	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6	DIM7
Before	3.85	3.91	3.81	2.83	3.75	3.39	4
	71.25%	72.75%	70.25%	45.75%	68.75%	59.75%	75%
After	3.88	3.93	3.9	3.17	3.84	3.41	4.04
	72%	73.25%	72.5%	54.25%	71%	60.25%	76%
P-value	NS	NS	NS	.023	NS	NS	NS

DIM= Dimension, NS= Non-Significant, n= percentage of participants, P-value= result of the T-Test

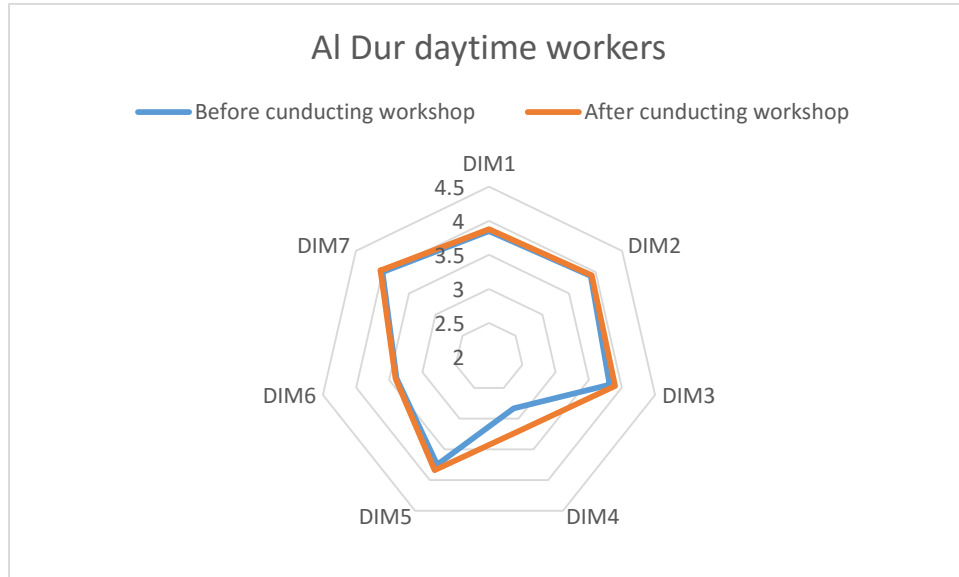


Figure (5.28) The variation in the level of safety climate before and after conducting safety workshop for Al Dur daytime workers as shown in table 5.17.

5.8 Definition of safety culture based on employees understanding

Referring to the feedback of the employees, a definition related to the power plant safety culture has been formulated as follow:

Safety culture in power plant is a concept that shapes it by attitudes, beliefs, perceptions and values related to the safe provision of the power plant and shared by the employees. Safety culture is created by the group and its level of awareness toward the safety issues. A good safety culture is a culture that prioritizes the safety with sitting shared goals by all the employees.

5.9 Results of the interviews

The answers of the interviews were varying in some aspects and agreed in many points, the summary of the interviews answers were summarized in table 5.18.

Table (5.18) A summary of the interviews' answers

Dimension	Interview questions	Summary of the answers
1. Management safety priority and ability	Is management balancing between production and safety?	There was variation in answers but 90% of the answers agreed that management gives attention to safety more than production. However, there was few cases (20% of the responses) where production became a priority and safety bypassed to a certain limit and with caution.
	How management manage safety?	80% of the participants agreed on the management high ability to manage safety, and the management always talks about safety. However, 40% focused on the importance of safety talks and it needs more attention from management.
2. Management safety empowerment	How employees participate in safety-related decisions?	In general, the answers points to the safety committee (90%), risk assessments (60%) and incidents reporting (30%). However, 40% emphasis on the need of improvement for incidents reporting system and communication in order to improve the learning and feedback process.
	How management create safe environment for working?	The answers point to applying safety rules (80%), safety rounds (30%), creating policies (60%) and providing safe equipment with periodic checks (90%).
3. Management safety justice	What is the investigation procedure for an incident?	There was no agreement on such a way for investigation but 80% of the participants said that the investigation will be done immediately after an incident with high confidentiality.
	What are the consequences of management after an incident?	There was an agreement that the consequences will be more about technical issues (70%) and the blame are not one of the consequences. Many of the participants agreed that the punishment would follow the investigation process (80%).
4. Workers safety commitment	How the workers commitment on safety?	The answers were varying, some said the commitment is high (50%) and others said that it is not the interest of everybody (40%). However, 90% of the answers point to the free talking about safety among employees and they discuss safety issues without restriction or fear.
5. Workers' safety priority	Are the workers balancing between	The answers are almost similar to the first question.

and risk non-acceptance	production and safety?	
6. Peer communication learning and trust in safety ability	How the workers are learning about safety?	Online courses (70%), applying for courses (50%) and asking questions (50%).
	How the workers working safely?	80% of the answers relate the work safely to competence and experience. 60% also said that the work will stop if any risk occurs.
	How safety issues are communicated?	Safety issues are communicated by talking about safety (60%) and sometime through the safety committee and communicated later to the employees (80%) and sometimes through e-mails (40%). However, 80% of the participants said that the communication process should be improved especially for shift workers.
7. Workers' trust in efficiency of safety systems	What is the effect of the following alternative on safety?	
	Safety representatives	30% said it has a positive impact, 20% said it has no effect, 30% said it depends on the experience and competency of the representative.
	Safety rounds	Generally has average impact (60%), except few cases that a safety round gave respected result (20%).
	Safety training	High impact positively (90%).
	Safety planning	High impact positively (80%).
	Clear defining of safety goals	It is important to define safety goals clearly (80%) but many goals are not clear (50%). The goals need somebody to follow up with it (40%).
Other	Why the safety climate level in Al Ezzel site is greater than Al Dur site?	The safety enhancement process started in Al Ezzel before Al Dur by certain time (50%), also the application of safety standardized safety rules began in Al Ezzel first (80%) and the management were located in Al Ezzel for longer period which gave it preference of enhancement(40%).
	Why there is large variation in the safety level within Al Dur site between shift workers and daytime workers?	The large number of shift employees, which reduce the control over them and reduce the effectiveness of the communication (60%) and the frequent changes in the shift rotation and timing of the shift (30%).
	Why the	(60%) of the participants relate this issue to

	management and safety department members have higher safety climate than the workers?	the lack of communication between the management and the workers.
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5.10 Suggested solutions to improve safety culture

After distributing set of suggestions among the managers and by seeking their opinions on those suggestions, the following is showing the order of solutions from the most effective to the less effective:

- 1- Use positive language: focus on the behavior you want, rather than talking about what you don't want.
- 2- Communicate the safety issues in different media.
- 3- Show the benefit of involvement in safety issues.
- 4- Seek feedback from the employees to insure the delivery of the message.
- 5- Bring international safety representatives to enhance the safety awareness.
- 6- Encourage workers in tackling the risks by incentives and rewarding systems.
- 7- Involve the workers in some safety decisions.
- 8- Conduct more toolbox talks by different people.
- 9- Involve the workers in determining safety goals.

Also by advising them to write their own suggestions, more solutions has been stated as shown below:

- 1- Provide incentives for the safety activities to encourage the employees to participate in the activities related to safety.
- 2- Assign some safety responsibilities to the employees.
- 3- Reward in public with showing the importance of that action and leave the blame to be in private.
- 4- Let everyone know what is expected from them.

Chapter six

Discussion

6.1 Method

6.2 Results

Chapter six

Discussion

6 Discussion

The methods used in the presented study as well as the results of the questionnaire and interviews are discussed in the present chapter with the comparison of the similar studies in the safety climate field.

6.1 Method

The evaluation of internal consistency of the all dimensions of the questionnaire showed positive results as the alpha coefficient values were between 0.55 and 0.81 with average of 0.73 (acceptable results). Prasad and Reghunath (2010) in construction field got alpha coefficient values between 0.791 and 0.827 with average value of 0.81 (good results). Bergh (2011) in chemical field got alpha coefficient values between 0.67 and 0.86 with average value of 0.778 (acceptable results). Also the stability test showed positive results as it has been found between 0.495 and 0.751 which indicate acceptable stability for the questionnaire, (Kines et al., 2011). Prasad and Reghunath (2010) in construction field, values got were between 0.80 and 0.95 which considered as (strong results). Therefore, the used questionnaire is considered a reliable tool to measure the safety climate in case of the thermal power plants.

As mentioned in methodology chapter, the validity of the questionnaire is insured through two steps. The first step was seeking the feedback of HSE department as expert in the field. The second step was conducting a pilot

study. A similar procedure, but with a larger scale, was followed by Arghami et al. (2014). Arghami et al. (2014) designed questionnaire for oil refinery. Their validity procedure includes seeking feedback of research team and experienced staff in the field of safety. In addition, a pilot study was conducted.

In the present study 32% of the questionnaire returned without fully answering the background questions, the possible reason for that is that some participants may thought that they will be recognized through the background information. Therefore, it should be stated in the questionnaire that the background information will not be presented in a way that will lead to participants' recognition.

In the present study, the samples include all the population (around 210) because it is finite. Including all the population can lead to increased accuracy for the results. Guldenmund (2010) and Bergh (2011) include all the population, which were around 480 and around 300, respectively. Prasad and Reghunath (2010) and Shirur and Torgal (2014), took sample of the population due to the large population.

The minimum response rate for a survey to be acceptable, depends on the size of the population, (Basarb, 2011; GreatBrook, 2014). In the presented work, 72.3% response rate had been achieved with around 152 out of 210 response. Basarb (2011) and GreatBrook (2014), mentioned that the minimum acceptable response rate for 200 sample size, is 66%. Bergh (2011) in chemical industry, achieved 69.4% response rate for sample size around 300. The minimum required response rate for 300 sample size is 56%, (Basarb, 2011; GreatBrook, 2014). Guldenmund (2010) in Service Company achieved 38.6% response rate for sample size around 480. The

minimum required response rate for 480 sample size is 47%, (Basarb, 2011; GreatBrook, 2014).

In the present study, the questionnaire distributed by hand with follow up. This way of distribution and collection, helped in increasing the response rate. The percentage of non-returned is due to busyness of the employee, so the employee will put the questionnaire aside and forgot about it, other reason is the unavailability of the employee during the distribution of the questionnaire, so it will be handed to someone else to give it later to the employee and this will lead to ignorance of the questionnaire.

As mentioned earlier, stratified sampling method had been used to select the samples for the interviews. This sampling method can insure that the chosen participants represent the different departments. The sample size was taken based on the comparison of previous studies. Guldenmund (2010) took around 10.5% of total population as sample size. Bergh (2011) took around 11.5% of total population as sample size. In the present work, 14% of total population as sample size for the interviews.

In the presented work, the response rate for the interviews was 33.3% (10 out of 30). This response rate is higher than Guldenmund (2010) and Bergh (2011), which are 22% and 25.7%, respectively.

The non-responded percentage may be caused by several reasons. First, the participants in the interviews cannot be anonymous. That may let many employees to turn down the invitation. Second, the invitation was sent by company e-mail. It is the main communication way in the company – and not face to face. The e-mail method results in easy ignorance for the invitation. Therefore, in order to increase the response rate, the invitation can be face to face with explaining the importance of the interview.

6.2 Results

As overall safety climate level for Al Ezzel O&M, it is considered as above average. The overall mean score of all results is 3.67 on scale of (1 to 5). The mean score for most of the dimensions were higher than 3 which is considered as a positive result, (Prasad and Reghunath, 2010; Bergh, 2011).

By dividing the workers into two main categories (daytime and shift workers) between the two sites, four groups can be identified. Al Ezzel daytime workers, Al Ezzel shift workers, Al Dur daytime workers, and Al Dur shift workers. Every group has seven dimensions. 28 dimensions had been calculated for its mean value. Out of the 28 dimension, only 3 dimensions scored less than 3. This can give an idea about the safety climate level of Al Ezzel O&M.

By investigating the two sites separately (table 5.3 and figure 5.11), a significant difference has been found in dimension 1 (Management safety priority and ability), dimension 4 (Workers' safety commitment) and dimension 6 (Peer safety communication learning and trust in safety ability). This indicates a gap in the safety climate level between the two sites. The answers of the interviews can clarify a reason behind this gap. The answers state that a difference may exist because the safety enhancement process started in Al Ezzel site before Al Dur site, alongside with applying of standardized safety rules in Al Ezzel before Al Dur. Other reason, the locating of management in Al Ezzel site gave Al Ezzel preference in adapting the safety rules and enhancing the safety communication and reporting.

As mentioned, the workers are divided into daytime workers and shift workers. The safety climates for each group for both sites have been studied in order to find out any sub-climate. When comparing the safety climate between daytime workers and shift workers of Al Ezzel power plant (table 5.10 and figure 5.18), a significant difference has been detected only in one dimension - dimension 1 (Management safety priority and ability) -which indicate high similarity between the two groups.

By comparing the safety climate between daytime workers and shift workers of Al Dur power and water production plant (table 5.11 and figure 5.19), a significant difference has been detected in dimension 1 (Management safety priority and ability), dimension 6 (Peer safety communication learning and trust in safety ability) and dimension 7 (workers' trust in efficiency of safety system). This indicates a gap between the two groups in Al Dur site. Referring to the interview answers, this variation is due to two main reasons, first is the size of the shift workers, which is relatively large, compared with the other groups, which reduce the effectiveness of communication. Second, Al Dur shift timing was changed many times.

In general, daytime workers have more safety climate level than shift workers do. The previous studies have showed that working near the line of production (in present work, shift workers) will affect the level of safety climate to be lower than the safety climate level of the other workers who work not near to the production (in the present work, daytime workers), (Collins & Gadd, 2002; Milczarek & Najmiec, 2004, Wu et al., 2007; Bergh et al., 2013). This can be seen similar to the present work results. The shift workers are working closer to the production which in this case: gas turbines, steam turbines, energized equipment and fuel gas filled systems

etc. Daytime workers are working most of the time far from production line, such as workshops and store.

Referring to tables 5.12 and 5.13 with its related figures 5.20 and 5.21, one can notice the significant difference between the shift workers of both sites and between the daytime workers of both sites. The daytime workers of Al Ezzel have higher safety climate than Al Dur daytime workers. In addition, the shift workers of Al Ezzel have higher safety climate than Al Dur shift workers. Again, it is the same reason as the difference exists between Al Ezzel and Al Dur site. According to Reason (1997), the level of safety climate can be affected by experiencing more accidents. By comparing the findings of Reason 1997 and the findings of present work, the same conclusion can be achieved. Referring to Al Ezzel O&M documents (2015), 65% of the near-misses were occurred in Al Dur site, while Al Ezzel site has 35%. According to present work results, Al Dur scored less safety climate level.

By comparing the safety climate level between the workers and managers (table 5.14 and figure 5.22) and by comparing the safety climate level between the workers and the safety department members (table 5.15 and figure 5.23), the managers and safety department members have higher level of safety climate than the workers. One possible reason is that the safety issues discussed between the management and safety department are not communicated effectively to the workers. This analysis is supported by the results of the interviews answers.

Factors other than the working site and the nature of the job were extracted from the background questions as follows: 1) age; 2) experience in Al Ezzel O&M; 3) number of working places; 4) number of attended safety

workshops; 5) years of experience in current position; 6) knowing of safety culture.

For the age as a factor (table 5.4 and figure 5.12), no clear relation revealed in the present work. In general the findings shows that younger workers (20-30 years) scored the highest level (4.25), and the middle category (31-40 years) scored the lowest (3.86). Bergh (2011) found that the younger workers scored less safety climate level (4.1). In addition, the older workers scored highest safety climate level. Wu et al. (2007) found the same relation as Bergh (2011). Due to this difference in the results of the presented work and other studies, further investigation on a wider number of workers required to reveal the age-safety climate relation.

For the experience in Al Ezzel O&M (table 5.5 and figure 5.13), significant relation has been found only in one dimension which is dimension 7 (workers' trust in efficiency of safety system). So, one can relate the building of trust to increased experience. The workers with less experience (1-3 years) scored less level of safety climate (3.81), and the workers with higher experience (more than 6 years) scored higher level of safety climate (4.22). The relation between experience in workplace and safety climate were discovered in different studies. In general, as the experience increased, the safety climate level increases (Wu et al. 2007; Beus, Bergman & Payne, 2010).

For number of workplaces (table 5.6 and figure 5.14), a clear and significant relation has been found with the safety climate. The workers with more workplaces scored higher safety climate level. One hypothesis for this is the workers with more workplaces have more experience in different

environments and different safety systems, which lead to higher safety awareness.

Analyzing the relation between the number of the safety workshops and the safety climate level (table 5.7 and figure 5.15) gave positive results. As the number of safety workshops increased, it will result in higher safety climate level.

The analysis of the relation between the experience in current position and the safety climate level (table 5.9 and figure 5.17) shows that highest level of safety climate (4.11) was in middle category (4-6 years) and the third category (more than 6 years) was lower (3.96) than the middle. The lowest score (3.93) was for the first category (1-3 years). This indicates a decrement in safety climate level after a long experience in the same position. The same conclusion was achieved by Bergh (2011), where the more experience in the same position resulted in less safety climate level.

41% of the employees do not know the safety culture (table 5.8 and figure 5.16) and they scored less safety climate level. The same results were found by Bergh (2011). One hypothesis to this result is the part that knows the safety culture may involve more in the safety activities and issues. It is important to define the safety culture to the employees to let them know what the company wants to improve in case the company started a plan to improve the safety culture.

For this reason, a definition of the safety culture was formulated, and it should be distributed over the employees.

To go into more detailed analysis, all the questions were analyzed individually (figures 5.24, 5.25, 5.26 and 5.27). The findings of the

individual questions helped in detecting some weak points within a dimension even if the dimension itself shows high level of safety climate. The numbers of weak questions were related inversely with the level of the safety climate level for each group. For example, Al-Ezzel site daytime workers have three weak questions and their safety climate score is 4.07 out of 5, while Al-Dur site shift workers have thirteen weak questions and their safety climate score is 3.37 out of 5.

By conducting a safety workshop for certain group with focusing on the weaknesses in safety climate for that group (table 5.17 and figure 5.28), the results showed significant improvement (increased by 8.5%) in one dimension - dimension 4 (Workers' safety commitment) - and the remaining dimensions has non-significant differences. By focusing on the importance of the involvement and by giving the keys to involve in the activities and decisions, the workers recorded improvement in this dimensions as they feel more involved and know the way to be active in the safety system. These results are a positive sign to the importance of the safety workshops in improving the safety culture. More improvement can be achieved by applying more improvement activities.

The presented study safety culture definition is: "Safety culture in power plant is a concept that shape itself by attitudes, beliefs, perceptions and values related to the safe provision of the power plant and shared by the employees. Safety culture is created by the group and its level of awareness toward the safety issues. A good safety culture is a culture that prioritizes the safety with sitting shared goals by all the employees." This definition can compared by the previous definitions that was mentioned earlier in the literature review. The word "attitudes" had been mentioned in ten

definitions, (Cox & Cox, 1991; Pidgeon, 1991; Ostrom et al., 1993; INSAG, 1991; Lee, 1996; Glendon & Stanton, 2000; Hale, 2000; Mohamed, 2003; CANSO, 2008; Guldenmund, 2010). The word “beliefs” had been mentioned in four definitions, (Cox & Cox, 1991; Pidgeon, 1991; Ostrom et al., 1993, Hale, 2000; Fang et al., 2006). The word “perception” had been mentioned in four definitions, (Cox & Cox, 1991; Lee, 1996; Kennedy & Kirwan, 1998; Hale, 2000). The word “values” had been mentioned in six definitions, (Cox & Cox, 1991; Lee, 1996; Glendon & Stanton, 2000; Hale, 2000; Fang et al., 2006; CANSO, 2008). The words “shared by employees” or “shared goals” had been mentioned in three definitions, (Cox & Cox, 1991; Hale, 2000; Cooper, 2000). The word “group” had been mentioned in five definitions, (Berends, 1996; Hale, 2000; Kennedy & Kirwan, 1998; CANSO, 2008). The word “awareness” had been mentioned in one definition, (Hale, 2000). Prioritizing safety had been mentioned in three definitions, (INSAG, 1991; Cooper, 2000, CANSO, 2008). Finally, relating the definition to the type of the sector itself appeared in two definitions, INSAG (1991) relate the safety culture to the nuclear plant, and CANSO (2008) relate the safety culture to the air navigations services.

Interviews were conducted to get more explanation about some issues. Parts of the interviews were used to get explanation for some issues that discovered by the questionnaire results, and this already discussed earlier in this chapter. The other part used to understand in details some points in the questionnaire. Bergh (2011) conducted interviews by assigning questions related to each questionnaire dimension in order to explain some questions in the questionnaire. However, Bergh (2011) did not put questions to seek explanations for the discovered issues. Unfortunately, other researchers did not explain how they made their interviews and did not show its structure.

Chapter seven

Conclusions and recommendations

7.1 Conclusions

7.2 Recommendations

7.3 Future work

Chapter seven

Conclusions and recommendations

7 Conclusions and recommendations

The fruit of this study is summarized in this chapter as well as giving recommendations to the company based on the findings. In addition, the possible future work is stated at the end of the chapter.

7.1 Conclusions

1- The results of studying the safety climate showed that the safety level of Al Ezzel site (3.92 out of 5) is higher than Al Dur site (3.49 out of 5). Therefore, Al Dur site needs more attention in any safety improvement process. The overall safety climate level of Al Ezzel O&M is above average (3.67 out of 5).

2- Two sub climates were detected within the company, daytime workers and shift workers. The sub climate appears obviously more at Al Dur site where the shift workers record less safety climate level. Al Ezzel daytime workers recorded safety level of (4.07) where the shift time workers recorded (3.82). Al Dur daytime workers recorded safety level of (3.62) where the shift time workers recorded (3.37).

3- The stability test for the questionnaire done by Interclass Correlation Coefficient (ICC), and it has been found between 0.495 and 0.751, which is considered as acceptable stability. The reliability test done by Cronbach alpha analysis, and it has found to be 0.68 as overall value for Al Ezzel

O&M workers, 0.72 for the managers and 0.78 for the safety department which considered acceptable, ideal and reliable.

4- The safety climate level for the managers is (4.13) and for the safety department is (4). Both scores are higher than the score for the workers of the company. A possible reason for this result is that the safety issues discussed between managers and workers is that the safety issues discussed management and safety department are not communicated effectively to the workers.

5- The weaknesses are few. For the day time workers of Al Dur site, only one dimension showed weakness, which is dimension 4 (Workers' safety commitment) that recorded (2.83). Moreover, for the shift workers of Al Dur, two dimensions showed weaknesses which are dimension 4 (Workers' safety commitment) with score of (2.89) and dimension 6 (Peer safety communication learning and trust in safety ability) with score of (2.92).

6- By conducting safety workshop for Al Dur daytime worker, an increase of 0.75% in the overall safety climate of this group with significant increase in dimension 4 (Workers' safety commitment) by 8.5%.

7- Four factors are affecting the safety climate level were identified clearly. First, the experience within the company, where the higher experience workers scored more safety level. Second, the experience with more workplaces resulted in higher level of safety. In addition, increasing the safety workshops helped in improving the safety level. Finally, by knowing what the meaning of safety culture is, the safety climate level can be increased.

8- The safety culture within Al Ezzel O&M were defined as: Safety culture in power plant is a concept that shape itself by attitudes, beliefs,

perceptions and values related to the safe provision of the power plant and shared by the employees. Safety culture is created by the group and its level of awareness toward the safety issues. A good safety culture is a culture that prioritizes the safety with sitting shared goals by all the employees.

7.2 Recommendations

As result of this report, many recommendations can be provided for the company. As general recommendations, the management should communicate the safety culture definition. It can use the formulated definition presented in the present study. By communicating the definition, shared understanding to safety culture concept can be created. The second recommendation is to decide on the wanted goal of safety climate level and create a plan for safety culture improvement based on the outcome of the analysis of the questionnaire and the interviews. In addition, all employees should be involved in some way in putting the action plan of improvement of safety culture to create shared goal among the employees. Finally, the improvement has to be followed up by re-evaluating the safety climate level every two or three years using the same questionnaire in order to be able to compare the results.

More recommendations to improve the safety culture is to improve safety communication by using variation of communicating ways to enhance safety awareness. And all employees should participate in setting goals related to safety. Also, perform job rotation in order to reduce the decline in safety level. Distribute the management timing among both sites. Finally, workshops to be attended frequently.

7.3 Future work

As future research, it is interesting to investigate the public sector in Bahrain as well as more private power plants with the possibility to expand to other sectors such as the oil, marine and health care. In addition, more investigation is required to the factors affecting the safety climate level such as age and years of experience in same position. Also, in the future more focus to be on interviews which can give more understanding for the safety issues.

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Appendices

Appendix A: OHSAS 18001

What is OHSAS 18001?

OHSAS 18000 is an international occupational health and safety management system specification. It comprises two parts, 18001 and 18002 and embraces a number of other publications.

OHSAS 18001 is an *Occupation Health and Safety Assessment Series* for health and safety management systems. It is intended to help an organizations to control occupational health and safety risks. It was developed in response to widespread demand for a recognized standard against which to be certified and assessed.

Who Created OHSAS?

OHSAS 18001 was created via a concerted effort from a number of the world's leading national standards bodies, certification bodies, and specialist consultancies. A main driver for this was to try to remove confusion in the workplace from the proliferation of certifiable OH&S specifications.

The participants were as follows:

- * National Standards Authority of Ireland
- * Standards Australia
- * South African Bureau of Standards
- * British Standards Institution
- * Bureau Veritas Quality International
- * Det Norske Veritas
- * Lloyds Register Quality Assurance
- * National Quality Assurance
- * SFS Certification
- * SGS Yarsley International Certification Services
- * International Safety Management Organisation Ltd

* Standards and Industry Research Institute of Malaysia

* International Certification Services

Benefits - How Can OHSAS Help?

The OHSAS specification is applicable to any organization that wishes to:

- Establish an OH&S management system to eliminate or minimize risk to employees and other interested parties who may be exposed to OH&S risks associated with its activities
- Assure itself of its conformance with its stated OH&S policy
- Demonstrate such conformance to others
- Implement, maintain and continually improve an OH&S management system
- Make a self-determination and declaration of conformance with this OHSAS specification.
- Seek certification/registration of its OH&S management system by an external organization

Essentially, OHSAS helps in a variety of respects... it helps: minimize risk to employees etc.; improve an existing OH&S management system; demonstrate diligence; gain assurance; etc. The benefits can be substantial.

OHSAS health and safety standard. (2015). *The Health and Safety & OHSAS Guide*. Retrieved from OHSAS health and safety standard: <http://www.ohsas-18001-occupational-health-and-safety.com/index.htm>

Appendix B: Safety Climate Questionnaire

Safety Climate Questionnaire

This questionnaire is designed to evaluate the safety climate level for Al Ezzel O&M. This is part of my thesis for the program of Master of Science in Engineering Management in University of Bahrain.

The questionnaire consists of two parts, which are (A) and (B). Part (A) includes general information related to your experience in the work, and part (B) includes the main questionnaire body, with 50 questions to evaluate the safety climate level.

(A) Background questions

You are kindly requested to answer the following questions:

- 1- Age ☐ 20-30 ☐ 31-40 ☐ 41-50 ☐ 51-60
- 2- Gender ☐ Male ☐ Female
- 3- Do you have managerial position? ☐ No ☐ Yes
- 4- Which of the companies do you work for? ☐ Al Ezzel ☐ Al Dur
- 5- Who is your closest manager/supervisor?
☐ Site manager
☐ Maintenance manager
☐ Operation manager
☐ Maintenance head
☐ HR manager
☐ HSE manager
☐ IT manager
☐ Planning manager
☐ Purchasing head
- 6- Do you work on a shift ☐ Yes ☐ No
- 7- How long have you been working at Al Ezzel O&M? ☐ 1-3 ☐ 4-6 ☐ more than 6 years
- 8- How long have you been working in your current position? ☐ 1-3 ☐ 4-6 ☐ more than 6 years
- 9- How many other workplaces have you had other than the ones at Al Ezzel O&M?
☐ 1-2 ☐ 3-4 ☐ more than 4
- 10- Where did you work before (you can choose more than one answer)? ☐ Power plant ☐ industrial sector ☐ non-industrial sector
- 11- How many safety workshop or training you attended? ☐ 1-3 ☐ 4-6 ☐ more than 6
- 12- Have you heard of the term “Safety culture” before? ☐ Yes ☐ No
- 13- Do you know what “Safety culture” is? ☐ Yes ☐ No

If 'yes', please describe your understanding of what safety culture is

(B) Safety climate evaluation

You are kindly requested to answer all the questions even if some seem to be similar. Please take your time

No.	1=strongly disagree	2=Disagree	3=Neutral	4=Agree	5= Strongly Agree	1	2	3	4	5
Dimension 1: Management safety priority and ability										
1	Management encourages employees here to work in accordance with safety rules even when the work schedule is tight.									
2	Relevant safety and health issues are always communicated.									
3	Management ignore any careless behavior in regard with safety.									
4	Management places safety before production.									
5	Minor/trivial accidents are tolerated as part of the job.									
6	We who work here have confidence in the management's ability to deal with safety.									
7	Management ensure immediate action to correct any discovered safety problem during rounds or evaluations.									
8	Safety and health has very high priority in my workplace.									
9	Management lacks the ability to deal with safety properly.									
Dimension 2: Management safety empowerment										
10	Management strives to design safety routines that meaningful and actually work.									
11	Management take in consideration the employees opinions in the decisions that affect their safety.									
12	Management makes sure that everyone can influence safety in their work environment.									
13	My line manager listens to my concerns about safety and health.									
14	Supervisors actively support safety.									
15	Management never asks employees for their opinions before making decisions regarding safety.									
16	Safety and health activities are limited to certain people in the plant.									
Dimension 3: Management safety judgment										
17	Management push hard to have accurate and precise information while investigating an accident.									
18	Fear of sanctions from management discourages employees here from report near-miss accidents.									
19	Management listens carefully to all who have been involved in an accidents.									
20	When accident occurs, management dig for the root causes and not the guilty persons.									
21	Management always blames employees for accidents.									
22	Management are prepared to discipline workers who act unsafely.									
Dimension 4: Workers' safety commitment										
23	People in my workplace want to achieve the highest levels of safety performance.									
24	We who work here take joint responsibility to ensure that the workplace is always kept tidy.									
25	On my site we have defined safety improvement objectives.									
26	Avoiding tackling the discovered risks is common behavior in the workplace.									

27	My colleagues and I help each other work safely.						
28	We who work here take no responsibility for each other's safety.						
Dimension 5: Workers' safety priority and risk non-acceptance							
29	Risks are unavoidable in our consideration.						
30	As part of our daily work, we consider minor accidents are normal.						
31	As long as there are no accidents unsafe behaviors are tolerated.						
32	It is sometimes necessary to take unsafe shortcuts to get the work done.						
33	We who work here never accept risk taking even if the work schedule is tight.						
34	Safety specific jobs always get done.						
35	We who work here accept risk-taking at work.						
Dimension 6: Peer safety communication learning and trust in safety ability							
36	We always trying to find solutions if someone discover safety problem.						
37	We feel safe while working together.						
38	Safety issues are included in communication meeting.						
39	What is learnt from accidents is used to improve safety training.						
40	We who work here take each other's opinions and suggestions concerning safety seriously.						
41	I have been shown how to do my job safely.						
42	We who work here rarely talk about safety.						
43	We who work here can talk freely and openly about safety.						
Dimension 7: Workers' trust in efficiency of safety systems							
44	We who work here consider that a good safety representative plays an important role in preventing accidents.						
45	Safety rounds or evaluations have no effect on safety, in our consideration.						
46	The safety training is very important to avoid accidents.						
47	We who work here consider that safety rounds/evaluations help find serious hazards.						
48	We who work here consider that early planning for safety as meaningless.						
49	The safety training I receive is not detailed enough for my job.						
50	We who work here consider it important to define safety goals clearly.						

Appendix C: Interview questions

- 1- Is management balancing between production and safety?
- 2- How management manage safety?
- 3- How employees participate in safety-related decisions?
- 4- How management create safe environment for working?
- 5- What is the investigation procedure for an incident?
- 6- What are the consequences of management after an incident?
- 7- How the workers commitment on safety?
- 8- Are the workers balancing between production and safety?
- 9- How the workers are learning about safety?
- 10- How the workers working safely?
- 11- How safety issues are communicated?
- 12- What is the effect of the following alternative on safety? Safety representatives, safety rounds, safety training, safety planning, clear defining of safety goals.
- 13- Why the safety climate level in Al Ezzel site is greater than Al Dur site?
- 14- Why there is large variation in the safety level within Al Dur site between shift workers and daytime workers?
- 15- Why the management and safety department members have higher safety climate than the workers?

Appendix D: Mean score calculation

Example for calculating means score for dimension 1

Individual	1	2	3	4	Mean score for dimension 1
Q1	5	4	5	5	
Q2	5	5	3	5	
Q3 (reverse)	4	3	3	4	
Q4	5	1	5	5	
Q5 (reverse)	2	1	2	3	
Q6	5	3	3	4	
Q7	4	2	5	4	
Q8	5	5	5	5	
Q9 (reverse)	1	4	4	4	
Mean score per individual	40/9= 4.44	30/9= 3.33	35/9= 3.88	35/9= 3.88	140/36= 3.88

Appendix E: Questionnaire of improvement suggestions

Please rate the following suggestion to improve the safety culture from 1 to 3 depend on the degree of effectiveness in the improvement process:

1: Low Effectively 2: Effective 3: High Effectively

No.	Suggestion	1	2	3
1	Involve the workers in some safety decisions			
2	Involve the workers in determining safety goals			
3	Show the benefit of involvement in safety issues			
4	Communicate the safety issues in different media			
5	Use positive language: focus on the behavior you want, rather than talking about what you don't want			
6	Seek feedback from the employees to insure the delivery of the message			
7	Conduct more toolbox talks by different people			
8	Encourage workers in tackling the risks by incentives and rewarding systems			
9	Bring international safety representatives to enhance the safety awareness			

Here you can write more suggestions that help to improve the safety culture:

Appendix F: Formulas used in Microsoft Excel for analysis

The data analysis part has been done using different formulas in Microsoft Excel software. Some formulas are embedded in the software itself such as T.test formula. Other formulas entered manually such as Interclass correlation coefficient. The following are the formulas used in Microsoft Excel software. All the groups' sizes are based on assumptions to simplify the formulas understandings.

1- Mean score value

Assume that we have eight participants. Every participant questionnaire result entered in one column. The participants' results occupy columns C to J.

- A) To calculate the mean value for first participant (column C) for every dimension and overall value, note that the data started in row number 2:

$$D1 = (C2+C3+(6-C4)+C5+(6-C6)+C7+C8+C9+(6-C10))/9 \rightarrow C53$$

$$D2 = (C11+C12+C13+C14+C15+(6-C16)+(6-C17))/7 \rightarrow C54$$

$$D3 = (C18+(6-C19)+C20+C21+(6-C22)+C23)/6 \rightarrow C55$$

$$D4 = (C24+C25+C26+(6-C27)+C28+(6-C29))/6 \rightarrow C56$$

$$D5 = ((6-C30)+(6-C31)+(6-C32)+(6-C33)+C34+C35+(6-C36))/7 \rightarrow C57$$

$$D6 = (C37+C38+C39+C40+C41+C42+(6-C43)+C44)/8 \rightarrow C58$$

$$D7 = (C45+(6-C46)+C47+C48+(6-C49)+(6-C50)+C51)/7 \rightarrow C59$$

$$\text{Overall} = \text{AVERAGE}(C53:C59) \rightarrow C61$$

D=Dimension

- B) To calculate the overall mean score value for all participants (Columns from C to J):

$$D1 = \text{AVERAGE}(C53:J53)$$

$$D2 = \text{AVERAGE}(C54:J54)$$

$$D3 = \text{AVERAGE}(C55:J55)$$

$$D4 = \text{AVERAGE}(C56:J56)$$

$$D5 = \text{AVERAGE}(C57:J57)$$

$$D6 = \text{AVERAGE}(C58:J58)$$

$$D7 = \text{AVERAGE}(C59:J59)$$

$$\text{Overall} = \text{AVERAGE}(C61:J61)$$

D=Dimension

2- T-test

Assume that the mean score value has been calculated for two groups. First group consists of ten participants and occupying the columns from B to K and the rows from 4 to 10. The second group consists of fourteen participants and occupying the columns from B to O and rows from 13 to 19.

A) To calculate probability value of the T-test for every dimension:

D1 =T.TEST(B4:K4,B13:O13,2,3)	→Q4
D2 =T.TEST(B5:K5,B14:O14,2,3)	→Q5
D3 =T.TEST(B6:K6,B15:O15,2,3)	→Q6
D4 =T.TEST(B7:K7,B16:O16,2,3)	→Q7
D5 =T.TEST(B8:K8,B17:O17,2,3)	→Q8
D6 =T.TEST(B9:K9,B18:O18,2,3)	→Q9
D7 =T.TEST(B10:K10,B19:O19,2,3)	→Q10

The first array in the formula is for the first group relative dimension. The second array is for the second group for the same dimension. Number 2 indicate two tailed test. Number 3 indicate two samples with unequal variance.

D=Dimension

B) To check for the significant difference. In this case $\alpha = 0.05$:

D1 =IF(Q4<0.05,Q4,"NS")
D2 =IF(Q5<0.05,Q5,"NS")
D3 =IF(Q6<0.05,Q6,"NS")
D4 =IF(Q7<0.05,Q7,"NS")
D5 =IF(Q8<0.05,Q8,"NS")
D6 =IF(Q9<0.05,Q9,"NS")
D7 =IF(Q10<0.05,Q10,"NS")

D=dimension

3- Cronbach Alpha coefficient

Assume that we have the results for 30 participants. They occupy the columns from B to AE. The example is for dimension 1 which consists of 9 questions per participants that occupy rows from 3 to 11.

A) To calculate the sum of the results for each participants:

P1 =SUM(B3:B11)	→B13
P2 =SUM(C3:C11)	→C13
.	
.	
P30 =SUM(AE3:AE11)	→AE13

P=Participant

B) To calculate the variance of the participants sums:

=VAR.P(B13:AE13)	→AG13
------------------	-------

C) To calculate the variance of each question of all participants:

Q1 =VAR.P(B3:AE3) →AG3

Q2 =VAR.P(B4:AE4) →AG4

.

.

Q9 =VAR.P(B11:AE11) →AG11

Q=Question

D) The summation of all questions variations (Qs)

=SUM(AG3:AG11) →AF15

E) Cronbach alpha value:

$r_a = (K/(K-1)) (1 - (\sum \sigma_i^2 / \sigma^2))$ where K is the number of questions

$r_a = (9/8) * (1 - (AF15/AG13))$

4- Interclass correlation coefficient

Assume we have one participant attempt the questionnaire twice with lapse of time.

The results entered in columns B and C, and it occupy the rows from 2 to 51.

Referring to the following equation, the formulas has been done:

r : correlation coefficient

n : number of objects (50 items)

x_{n1} : the first rating (cells from B2 to B51)

x_{n2} : the second rating (cells from C2 to C51)

$\bar{x} = 1/2n (\text{SUM} (x_{n1} + x_{n2}))$

$S^2 = 1/2n (\text{SUM} (x_{n1} - \bar{x})^2 + \text{SUM} (x_{n2} - \bar{x})^2)$

$r = 1/nS^2 (\text{SUM} ((x_{n1} - \bar{x})^2 (x_{n2} - \bar{x})^2))$

A) To calculate ($x_{n1} + x_{n2}$) of each question:

P1 = B2+C2 →D2

P2 = B3+C3 →D3

.

.

P50 = B51+C51 →D51

P=Pair

- B) To calculate the summation of $x_{n1} + x_{n2}$:
 $=\text{Sum}(\text{D2:D51})$ →D53
- C) To calculate $\bar{x}$:
 $\bar{x} = (1/50)*(\text{D53})$ →B54
- D) To calculate $(x_{n1} - \bar{x})^2$ and its summation:
 $\text{Q1} = (\text{B2}-\text{B54})*(\text{B2}-\text{B54})$ →E2
 $\text{Q2} = (\text{B3}-\text{B54})*(\text{B3}-\text{B54})$ →E3
. .
 $\text{Q51} = (\text{B51}-\text{B54})*(\text{B51}-\text{B54})$ →E51

Q=Question

 $=\text{Sum}(\text{E2:E51})$ →E53
- E) To calculate $(x_{n2} - \bar{x})^2$ and its summation:
 $\text{Q1} = (\text{C2}-\text{B54})*(\text{C2}-\text{B54})$ →F2
 $\text{Q2} = (\text{C3}-\text{B54})*(\text{C3}-\text{B54})$ →F3
. .
 $\text{Q51} = (\text{C51}-\text{B54})*(\text{C51}-\text{B54})$ →F51

Q=Question

 $=\text{Sum}(\text{F2:F51})$ →F53
- F) To calculate S^2 :
 $S^2 = (1/50)*(\text{E53}+\text{F53})$ →B55
- G) To calculate $(x_{n1} - \bar{x})^2 (x_{n2} - \bar{x})^2$ and its summation:
 $\text{P1} = \text{E2}*\text{F2}$ →G2
 $\text{P2} = \text{E3}*\text{F3}$ →G3
. .
 $\text{P51} = \text{E51}*\text{F51}$ →G51

P=Pair

 $=\text{Sum}(\text{G2:G51})$ →G53
- H) To calculate r :
 $r = (1/50/\text{B55})*(\text{G53})$

ملخص الرسالة

السلامة هي واحدة من أهم القضايا لدى العاملين في القطاع الصناعي. السلامة تحوي عدة مفاهيم و مواضيع مثل ثقافة السلامة و بيئة السلامة. ثقافة السلامة و بيئة السلامة تعتبران من أهم المواضيع حالياً في القطاع الصناعي. هذان الموضوعان لا يزالان غير معروفان بتعريف متفق عليه عالمياً، و لكن بالبحث يمكن الحصول على عدة تعاريف لهما. كتعريف بسيط لثقافة السلامة: " كل ما نقوم به يهدف لضمان عدم إصابة الآخرين بسوء". بيئة السلامة يمكن تعريفها كالآتي: " بيئة السلامة هي مفهوم يصف أخلاقيات السلامة في المنظمة أو مكان العمل و الذي يعكس معتقدات الموظفين عن السلامة".

في هذه الأطروحة، تم تقييم بيئة السلامة على إعتبار أنها إنعكاس لثقافة السلامة، و هي تعتبر أداة سريعة لتقييم ثقافة السلامة بأقل الموارد المطلوبة. تقييم بيئة السلامة تمت لمحطتين للطاقة خاصة و هما محطة العزل للطاقة و محطة الدور للطاقة و إنتاج المياه. كلا المحطتين تقعان في البحرين و تتم إدارتهما بواسطة شركة العزل للعمليات و الصيانة. عملية التقييم تمت بواسطة استبيان لجميع الموظفين (حوالي 200 موظف). الاستبيان تم تصميمه بالرجوع الى الدراسات السابقة. بالإضافة للاستبيان، تم عمل مقابلات لدعم نتائج الاستبيان. جميع النتائج تم تحليلها باستخدام برنامج الميكروسوفت لمعالجة الجداول.

نتائج تقييم بيئة السلامة أوضحت أن مستوى السلامة في شركة العزل للعمليات و الصيانة فوق المتوسط (3.67 من 5). بالإضافة لذلك، مستوى السلامة في محطة العزل (3.93) أعلى من مستوى السلامة في محطة الدور (3.49). بدراسة مستوى السلامة لمختلف الأقسام تم تقسيم العمال لأربع مجموعات، و هي: 1) عمال الفترة النهارية لمحطة العزل. و 2) عمال النوبات لمحطة العزل. و 3) عمال الفترة النهارية لمحطة الدور. و 4) عمال النوبات لمحطة الدور. أيضاً، هذه الدراسة أسفرت عن تحديد عدة عوامل تؤثر على مستوى السلامة، مثل: طبيعة العمل، و سنوات الخبرة، و عدد ورشات العمل التي حضرها العامل في مجال السلامة.

عدد من التوصيات تم الاشارة اليها مثل توضيح تعريف ثقافة السلامة لجميع الموظفين و اعادة تقييم بيئة السلامة بشكل دوري.

جامعة البحرين

قسم الهندسة الميكانيكية

كلية الهندسة



تحليل بيئة السلامة في محطة كهرباء

بحث لاستكمال متطلبات الحصول على درجة (الماجستير) في برنامج الإدارة الهندسية

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