



Faculty of Science and Technology

## MASTER'S THESIS

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Author: Binghe Chen	.....  (Signature author)
Faculty supervisor: Professor: Tore Markeset	
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## **ABSTRACT**

With global economy rapidly grows and strong social needs, energy has become an important strategic resources for national development. Although many countries are making great efforts to develop sustainable energy such as wind, nuclear, hydro and solar, undoubtedly, petroleum and natural gas still dominate in global energy demands.

However, Due to drilling platform has characteristic of high risk, almost all of petroleum companies have a common view - safety first, apply high reliable equipment, adopt optimized hull structure design, and establish safety management regulations to control and relief risk and danger, however, these safety facilities and safety systems could not achieve essential safety. Specially, “Deepwater Horizon spill oil” accident had been the biggest disaster in the history of the drilling industry. Most of people considered that if a drilling platform or a drilling company pursues state of essential safety, it will need to have an excellent safety culture.

In this paper, by analyzing the different drilling companies HSE concept, safety performance, training, incentive, equipment selection and case study to identify drilling company’s safety culture and rig’s safety culture in international working environment.

A good safety culture can be as an example to learn, but it is not possible to completely graft a safety culture from a drilling rig to others, as each organization is unique, and the best safety systems in the world will fail without a supportive culture.

Attitudes, personal education and experience, organizational training, communication mechanism and so on, all of them affect the development of a safety culture in a drilling rig. The environment in which people work and the systems and processes in a drilling rig also influence the safety culture. Therefore, each drilling rig needs to consider all of these aspects in developing and nurturing a safety culture that suits the rig and the individuals within it.

The research and conclusion of this paper could provide useful drilling rig’s safety culture model to promote drilling rig’s safety performance and safety management .

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## **Chapter One: Introduction**

### **1.1 Researching background and significance**

With global economy rapidly grows and strong social needs, energy has become an important strategic resources for national development. Although many countries are making great efforts to develop sustainable energy such as wind, nuclear, hydro and solar, undoubtedly, petroleum and natural gas still dominate in global energy demands.

It is well-known that the USA is the world's largest oil consumer, and it is also the largest oil-importing country. In recent years, the U.S. government is advocating and pulling the development and research of new energy and sustainable energy, which also makes oil consumption in the United States has declined, however, in worldwide, demands of petroleum and natural gas are growing rapidly in some emerging developing countries, due to their rapid economic growth, such as China, Brazil and India.

Take demands of Chinese petroleum and natural gas as a example, in 2013, China energy market analysts believe that Chinese petroleum demand will continue to increase, it predicted may reach 493 million tons, growth rate is 5%. This predictive data is higher than the market demand in 2012. The activities of Chinese petroleum and natural gas exploration and development maintains strong growing momentum, the investment will continue to maintain double-digit growth. Hot spots of exploration and development will tend to deepwater, unconventional oil and gas, and LNG. In China, government is pulling process of industrialization and urbanization, therefore, natural gas demand rapidly grows. Marketing experts predict that Chinese demand for natural gas in 2012 from 130 billion cubic meters will increase to 273 billion cubic meters in 2017. China will become the world's third largest natural gas consuming country.

Take demand of Brazilian petroleum as an example, in 2012, Brazil need to consume crude oil 319 million barrels per day on average, this data was more than Saudi Arabia's 311 million barrels per day, therefore, Brazil had become the world's sixth-largest oil consuming country, the top five were the USA, China, Japan, Russia and India. Brazil's growth rate of average daily oil consumption reached to 2.7% in 2012.

Take demands of Indian petroleum and natural gas as an example, India's Energy Ministry said recently that, due to domestic natural gas production was stagnant in 2012; India might become a net importer of natural gas in the future. To support economic development, India had to spend considerable financial capital to import expensive liquefied natural gas (LNG). Indian import demand of petroleum was as high as 79%, and expected to be an annual growth rate of 6%.

In fact, petroleum and natural gas are important driven powers of national economic and social development, effectively provide protection of national security, and at the same time, petroleum and natural gas also bring considerable economic income for countries and petroleum companies. In the international background of global oil and natural gas demands, many countries and petroleum companies are actively promoting petroleum and natural gas exploration and development. Current onshore oil resources gradually drying up have been an indisputable fact, 60% annual new oil production is produced from offshore exploration, which makes many countries and petroleum companies full of strong interest in offshore oil exploration and development. However, offshore oil exploration and development compared with onshore, it has characteristics of harsh environment, complex technology, difficult construction, high investment and high risk, risk not only refer to investment risk and personnel security risk, it also includes downhole risk, equipment risk, environmental pollution risk, petroleum companies also bear more social responsibility, compared to other industries, safety management in offshore oil exploration and development is more complex and important.

China Offshore Petroleum Exploration Bureau of the Petroleum Ministry, BoHai No.2 drilling platform sank at in towing operation at BoHai Bay in the early hours of November 25th, 1980. The accident resulted in fatality of 72 drilling workers, direct economic losses of 3700 million. Since the founding of China, BoHai No.2"drilling platform sinking accident is the most significant fatalities, it is also rare in the world history of offshore oil exploration.

20<sup>th</sup> April.2010, the day is a nightmare disaster for world. In the U.S. Gulf of Mexico, "Deepwater Horizon" drilling platform occurred a serious accident, and resulted in blowout and hull sunk, fatality of 11 drilling workers. This is the most serious in the history of offshore oil pollution. Unbelievably, 10 weeks after the accident, all famous experts around the world could not offer feasible way to solve the blowout. In the end, the entire accident caused to leak 5000 thousand barrels of crude oil.

Due to lack of consideration of the weather conditions and violations of safety rules, Russian jack-up drilling rig sank off the eastern coast of Russia near the island of Sakhalin in 19th.Dec.2011, while being towed. The rig was being towed to the port city of Kholmsk when a storm rolled in. Strong winds and high waves caused the drill rig to sink. The rig sank in 20 minutes. Fourteen members of the crew were rescued, and four bodies have been recovered. The remaining 49 crew members were still missing.

Due to drilling platform has characteristic of high risk, almost all of petroleum companies have a common view - safety first, apply high reliable equipment, adopt optimized hull structure design, and establish safety management regulations to control and relief risk and danger, however, these safety facilities and safety systems could not achieve essential safety. If a drilling platform or a drilling company pursues state of essential safety, it will need to have an excellent safety culture.

Safety culture is one of the important symbols of the modern drilling rigs and drilling company's safety management construction, it is an important part of safety management, and is also a form of safe values.

The three significances of safety culture in modern drilling rig:

- (1) A good safety culture construction can promote effectively safety management and deliver good safety performance for drilling rig.
- (2) Benefit for eliminating hidden danger, correcting violation operation, and to ensure the implementation of safety procedures in drilling rig.
- (3) A good safety culture construction is an effective guarantee for the effective implementation of safety investment.
- (4) Enhance employee's safety awareness from top to bottom in drilling rig.

## **1.2 The importance of this topic**

From BoHai No.2 in 1980 to Deepwater Horizon in 2010, it is obvious that drilling rig operations have characteristics of high risk and labor intensive. Once serious accident occurred in drilling rig, it would result in fateful environment, personnel and equipment losses. New constructed drilling rigs continue to adopt new techniques and technologies and promote equipment capability in preventing such accidents, however, only depend on promoting equipment capacity, which cannot really prevent accidents. To achieve aim of zero accident, drilling rig should build good safety management system and excellent safety culture.

In accident of BP Deepwater Horizon oil spill, the immediate causes of the Macondo well blowout were attributed to a series of identified mistakes that expose such systematic failures in risk control and management, this accident also caused that the public began to disbelieve the safety culture of drilling industry.

Based on past experience, analysis of accidents often shows that warning signals prior to the incident have been missed at optimum time. Warning signals missed, which can be considered as several factors, including the unique characteristics of the drilling industry, low standards of operating requirement, weak working discipline and lack to commitment of leadership.

All of these factors can be incorporated into aspect of safety culture; an excellent safety culture can promote effectively safety performance with positive effect. An organization should create and sustain a good safety culture, especially in drilling industry, it can help organization and company to identify personnel behaviors and attitudes what are right, safety culture encourages to reward right behaviors and attitudes, because rewarding is more effective than punishing.

An excellent safety culture can reduce accidents and keep on-site workers safe, finally establishing a more complete and mature system to achieve zero accident. The benefits of safety culture also include that enhancing operating discipline, promoting



operating standards, increasing productivity and encouraging worker morale.

If an organization or company can deliver a good safety culture, it will need leadership and managers to actively diagnose issues and act to correct mistakes, and make supportive and collaborative function of an safety department to spread over broader organizational effectiveness.

### **1.3 Researching scope defined**

The scope of this paper is to collect and analyze drilling rig's accident cases, find out root causes of accidents, summarize lessons learned from accident. Though these lessons learned, to get safety culture's influence factors. Based on these influence factors, associated with literature review and information collected to build a drilling rig's safety culture model, aiming on identify drilling rig's safety culture aspects in international working environment.

### **1.4 Researching main goal and secondary goals**

This paper through deeply researches the relationship between safety culture and its impact elements to identify grade of safety culture in international offshore drilling industry.

Researching main goals is:

- (1) Identification of safety cultural aspects on drilling rigs with international working environment.

Researching secondary goals include:

- (1) Research the safety culture associated with its main influence factors.
- (2) Build drilling rig's safety culture model

Through this paper's researching, it is benefit for improving safety culture of drilling rig and drilling worker's safety awareness in different phases of safety management, in order to promote safety performance, prevent accidents and ultimately achieve accident-free operating environment.

### **1.5 Research limitation**

This paper researches and discusses safety culture influencing factors of drilling rig, and build safety culture model of drilling rig. These influence factors of safety culture are based on literature study, analyzing Transocean and Diamond Offshore drilling company's safety management as well case study, due to samples are only two drilling companies, so safety culture influencing factors may be one-sided in a certain degree. In case study, part of the causes of the accidents are analyzed by my working experience and accident analysis chart of COSL Drilling Company, so some causes of accidents exist subjectivity in a certain degree. In the analyzing and discussing safety management of two drilling companies, a lot of information is from their websites, so the conclusions of discussion depend on authenticity of their information.

## **Chapter Two: Safety management theory and practice**

### **2.1 Safety concept**

During the development of human society, safety has become the most basic condition for human beings to survive and develop, which is an entire human consensus. The word of safety has a comprehensive meaning; in general, safety means that relative freedom from danger, risk, or threat of harm, injury, or loss to personnel and/or property, whether caused deliberately or by accident.

On the point of view of engineering to explain safety, safety means ascertainable risk does not exceed the allowable limit, so-called risk refers to ascertainable risk of the probability of occurrence and harm exceed allowable limit.

On the point of view of labor to explain safety, safety means that working personnel should avoid unacceptable risk, or injury or death of personnel, the state or condition of the property is lossless.

Safety is only relative, in the development of human society, safety is not absolute. One hand, with increasing level of human perception, some of the original safe states thought change into unsafe. On the other hand, only science and technology gradually develop into a high level, human has enough ability to eliminate risks or solve safety problems that cannot be solved in the past.

In different economic conditions, safety needs are different. The more developed society and economy, acceptable level of risk is lower, therefore demanding more safety requirements.

In summary, safety means that state of human psychology, health, equipment and environment is not endangered by external risk factors.

### **2.2 Safety awareness**

#### **2.2.1 Awareness**

It is difficult to make an exact definition for awareness. Some people think that awareness possesses a stratified feature, it can be divided into several factors, like feeling, memory, imagine, understanding, reaction and attention and so on, and feelings and memories belong to basic elements. Also some scholars pointed out that external awareness is organisms and their own psychological and physiological activities of objective awareness or experience. In general, so far, awareness is still a relatively fuzzy and incomplete concept.

### **2.2.2 Safety awareness**

Safety consciousness is getting wide attention in worldwide. Many experts and scholars made definitions of safety awareness from different angles.

On the point of view of personnel safety to explain safety awareness, so-called safety awareness mean that safety responsibility is to attribute oneself, and not to overestimate own self-confidence; take a cautious attitude to control oneself behavior.

On the point of view of safety production practice to explain safety awareness, safety awareness should be established in people's minds to actively pursue safety working state, and it is reflection of safe production of objective reality in the human consciousness. The lessons learned from past accidents could self-consciously form safety production requirement on people's psychology. Based on people's understanding and mastery of objective laws of the safety production, safety awareness could protect workers themselves to avoid injury and harm.

On the point of view of safety management to explain safety awareness, it belong to conscious field, it is aiming reflection on safety production technology, design, a series of safety production regulations and so on.

On the point of view of psychology to explain safety awareness, it is a kind of alert psychological state for external environment which can cause personnel injury in the process of production. The safety awareness includes two aspects. One aspect is people's judgment, evaluation, understanding for objective external environment, and another aspect is people's behaviors that are decided by the consequences of judgment and understanding to guarantee safety. Workers' safety awareness contains safety knowledge, safety laws and standards, safety skills, safe production environment conditions and so on.

From above mention, the awareness applied in safe field which is called safety awareness. Safety awareness refers that objective safety state is reflected on people's subjective thinking, the degree of safety awareness is decided by people's understanding level, as well as continuously adjusting self-behavior to reach safety self-consciousness.

### **2.2.3 Type of safety awareness**

Type of safety awareness

People's safety awareness is very complex, and everyone's safety awareness state is different. From the point of view of the human's safety representation to group into three types, namely emergency, indirect, superior safety awareness.

#### **(1) Emergency safety awareness**

Emergency safety awareness means that hazard factors are obvious, and they can directly cause danger and injury. For these hazards, workers can quickly detect, and

take urgent measures to avoid them. Such safety awareness is based on spontaneous, instinct reaction.

(2) Indirect safety awareness

Indirect safety awareness mainly reflected in hidden hazard factors. Workers can consciously take safe protective measures (like isolation and warning tape) to avoid risks and dangers. In general, the dangerous consequences hidden are difficult to be detected without safety education and training.

(3) Superior safety awareness

It refers that workers can take preventive measures to eliminate hazard factors which are in a latent state, and not emerge any effects. This kind of safety awareness is a relative high requirement.

#### **2.2.4 Three key elements of safety awareness**

Awareness is a structure of the system, and its activity is multifaceted, multi-layered. Safety awareness is one of awareness, so it also exists in structure. In safety awareness, the structure has three key elements: human natural force, mastery and use of safety knowledge and experience, willpower and emotion.

(1) Human natural force

This is the substantial basis of the structure of the safety awareness. Human kind has the ability to adapt to nature, and achieve Interaction with own power.

(2) Mastery and use of safety knowledge and experience

This is the intelligence factor structure of safety awareness. In safety, it refer that human gradually understand safe objective laws, and summarize safe knowledge and experience. Safety knowledge mastered is more profound and more comprehensive, in activities engaged; human's safe consciousness is higher.

(3) Willpower and emotion

This is a spiritual element of in the structure of the safety awareness. Human's emotion is feeling and evaluation of safe state. It is expressed as the degree of attention of the safe work, the hatred of illegal operations, longing for a safe and healthy working environment, satisfied psychology and mental activity for safe facilities.

In safety awareness structure, the three elements are interacting. Spiritual and intellectual elements are built on the basis of a certain substance, at same time; substantial basis is also counterproductive in spiritual and intellectual elements. Human only coordinate well the relationship between the three elements of safety awareness, and develop fully the positive aspect of the three elements, in order to improve safety awareness and security capabilities.

#### **2.2.5 Characteristics of safety awareness**

In general, most of safety managers consider that safety awareness includes six

characteristics in industrial production environments.

- (1) Consciousness of safety awareness
- (2) Directiveness of safety awareness
- (3) Predictability of safety awareness
- (4) Initiative of safety awareness
- (5) Conditionality of safety awareness
- (6) Plasticity of safety awareness

### **2.3 Safety management theory**

Before safety management theory appeared, people used fatuous fatalism to explain accidents; the causes of accident are attributed destiny and punishment of the gods. Therefore, people always passively accepted the consequences of the accident. With the advent of industrialization, industrial accidents appeared frequently. In the United States and Europe, some scholars had begun to attach importance to the study of the safety management, therefore, which led to emergence and development of the theory of scientific safety management.

The early safety management theory revolves around a theme, that is, to analyze the cause of the accident.

Accidents are defined as unplanned occurrences which result in injuries, fatalities, loss of production or damage to property and assets. Preventing accidents is extremely difficult in the absence of an understanding of the causes of accidents. Many attempts have been made to develop a prediction theory of accident causation, but so far none has been universally accepted.

#### **2.3.1 Accident proneness theory**

Among a population, a small proportion of people are much more likely to get involved in accidents than others, this phenomenon is called accident proneness (AP), first noted by Greenwood & Woods. The early work on this dates back to 1919, in a study by Greenwood and Woods, who studied workers at a British munitions factory and found that accidents were unevenly distributed among workers, with a small proportion of workers accounting for most of the accidents (Greenwood, M. and Woods, H.M., 1919). Further work on accident-proneness was carried out in the 1930s and 1940s.

#### **2.3.2 Domino theory**

According to W.H. Heinrich in 1931, who developed the so-called domino theory, 88 of all accidents are caused by unsafe acts of people, 10% by unsafe actions and 2% by ,“acts of God”. He proposed a “five-factor accident sequence” in which each factor would actuate the next step in the manner of toppling dominoes lined up in a row (Heinrich, H.W., 1931). The sequence of accident factors is as follows:

- Ancestry and social environment
- Worker fault
- Unsafe act together with mechanical and physical hazard
- Accident

➤ Damage or injury

Extending the domino metaphor, an accident was considered to occur when one of dominos or accident factors falls and has an ongoing knock-down effect ultimately resulting in an accident (Figure 1).

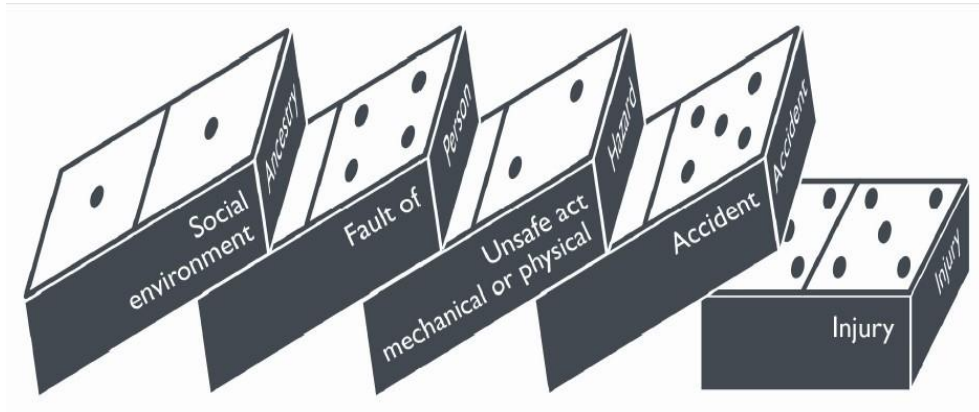


Figure 1: Domino model of accident causation (modified from Heinrich, 1931)

In the same way that the removal of a single domino in the row would interrupt the sequence of toppling, Heinrich suggested that removal of one of the factors would prevent the accident and resultant injury; with the key domino to be removed from the sequence being number 3. Although Heinrich provided no data for his theory, it nonetheless represents a useful point to start discussion and a foundation for future research.

### 2.3.3 Energy model

Gibson's (1961) and Haddon's (1968) energy models, using a closed system safety mindset, with mechanistic metaphors that describe conditions, barriers and linear causal chains of an accident process. They considered that accident what is an abnormal, or unexpected energy release can cause directly harm, therefore, should control energy, or control energy vector to prevent accidents. William Haddon's (1968) "Energy Damage and the Ten Countermeasure strategies" are a list of ten actions to take to reduce the consequences of "energy transfer", energy being in the forms of kinetic, thermal, chemical, electrical, biological, acoustic and ionizing radiation. Damage or injury results when energy is.

### 2.3.4 "Swiss Cheese" model

Reason's early work in the field of psychological error mechanisms was important in this discussion on complexity of accident causation. By analyzing routine working faults and accidents, he developed models of human error mechanisms. Reason pointed out to address the issue of two kinds of errors: active errors and latent error, the kinds of errors tended to lie dormant in the system largely undetected until they combined with other factors to breach system defenses. Reason considered that accidents were not solely due to individual operator error (active errors) but lay in the wider systemic organizational factors (latent conditions) in the upper levels of the organization

(Reason, J.T., 1990). Reason's model is commonly known as the "Swiss Cheese" Model.

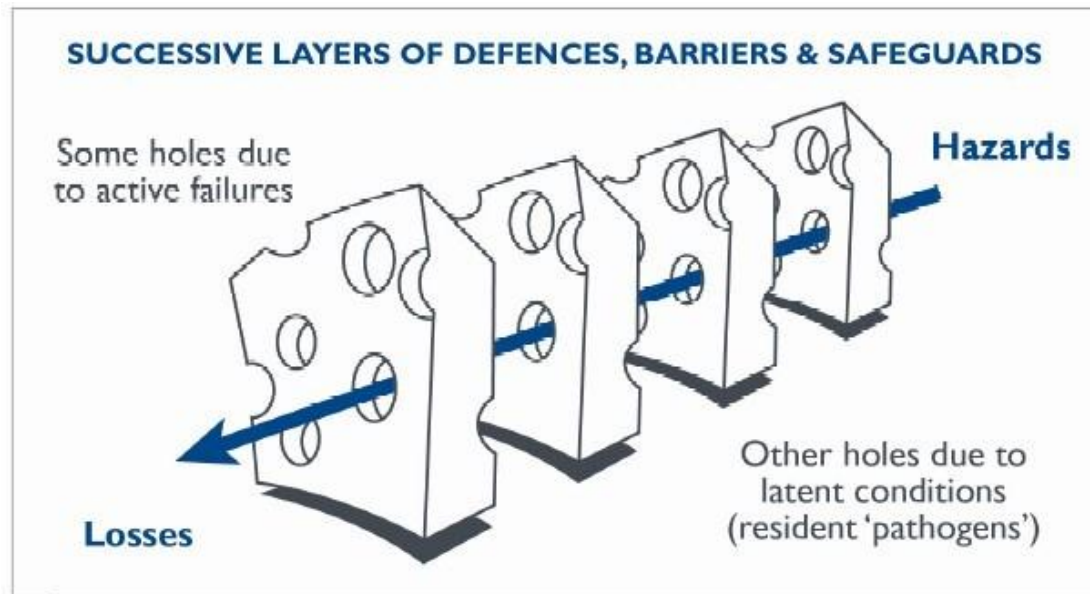


Figure 2: Reason's Swiss Cheese Model (Modified from Reason, 2008 p.102)

### 2.3.5 Systems Theoretic Approach

After World War II, technology expanded rapidly and engineers were faced with designing and building more complex systems than had been attempted previously. Much of the impetus for the creation of this new discipline came from military programs in the 1950s and 1960s, particularly ICBM systems. Apollo was the first nonmilitary government program in which systems engineering was recognized from the beginning as an essential function (Richard C. Booten Jr. and Simon Ramo., 1984). New approaches to accident modeling adopt a systemic view which considers the performance of the system as a whole. In systemic models, an accident occurs when several causal factors (such as human, technical and environmental) exist coincidentally in a specific time and space (Hollnagel, E., 2004). Systemic models view accidents as emergent phenomena, which arises due to the complex interactions between system components that may lead to degradation of system performance, or result in an accident. Systemic models have their roots in systems theory. Systems theory includes the principles, models, and laws necessary to understand complex interrelationships and interdependencies between components (technical, human, organizational and management). In a systems theory approach to modeling, systems are considered as comprising interacting components which maintain equilibrium through feedback loops of information and control. A system is not regarded as a static design, but as a dynamic process that is continually adapting to achieve its objectives and react to changes in itself and its environment. The system design should enforce constraints on its behavior for safe operation, and must adapt to dynamic changes to maintain safety. Accidents are treated as the result of flawed processes involving interactions among people, social and organizational structures,

engineering activities, and physical and software system components (Leveson, N.,2004).

## 2.4 Safety management practice

For promoting safety level of manufacture system, most of companies desire to achieve overall guidance of safety management practice: prediction of dangerous accident, discovery of accident's potential, control of unsafe statement, decrease of accident's affection, safety control of design and implement.

Some companies preferred to use the following methods below to judging reasons of safety problems and safety statement.

### 2.4.1 Cause & Effect (Fishbone Diagram)

The Ishikawa Diagram, also known as the Fishbone Diagram or the Cause-and-Effect Diagram, is a tool used for systematically identifying and presenting all the possible causes of a particular problem in graphical format. The possible causes are presented at various levels of detail in connected branches, with the level of detail increasing as the branch goes outward, i.e., an outer branch is a cause of the inner branch it is attached to. Thus, the outermost branches usually indicate the root causes of the problem.

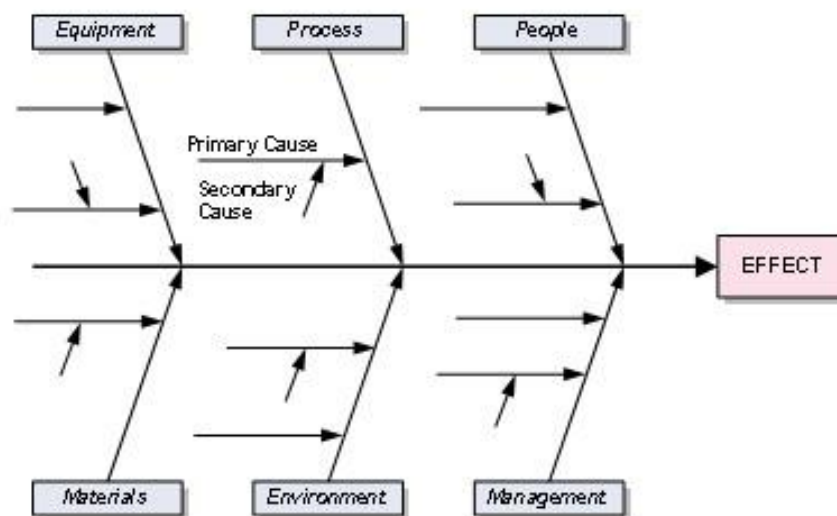


Figure 3: Cause & Effect Diagram

### 2.4.2 Safety Evaluation

Safety evaluation is for guarantee of safety. According to the scientific process and methods, prior estimate, analysis and estimation from potential dangerous of industrial production. Thus, control and eliminate objective existence of dangerous factors.

Generally, safety evaluations are mainly concentrate on four aspects: distinguish of



dangerous, ration of dangerous, compare of base rate, measures of dangerous controlling. It should be adjusted according to the practical situation in different industries and different characters.

The methods of safety evaluation are divided into categories below:

- Safety check list (SCL)

SCL is a list of things which have to be checked as part of safety regulations. In the evaluation of SCL, all factors which could have led to dangerous are included. After all SCL finished, people will have a general acknowledge of enterprise's safety statement, then objectively control safety and figure out dangerous.

- Process Hazard Analysis (PHA)

PHA is a set of organized and systematic assessments of the potential hazards associated with an industrial process. A PHA provides information intended to assist managers and employees in making decisions for improving safety and reducing the consequences of unwanted or unplanned releases of hazardous chemicals. A PHA is directed toward analyzing potential causes and consequences of fires, explosions, releases of toxic or flammable chemicals and major spills of hazardous chemicals, and it focuses on equipment, instrumentation, utilities, human actions, and external factors that might impact the process.

- hazard and operability study (HAZOP)

HAZOP is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation. The HAZOP technique was initially developed to analyze chemical process systems, but has later been extended to other types of systems and also to complex operations such as nuclear power plant operation and to use software to record the deviation and consequence. A HAZOP is a qualitative technique based on guide-words and is carried out by a multi-disciplinary team (HAZOP team) during a set of meetings.

- Fire and Explosion Index (F&EI)

F&EI is a tool to help determine the areas of greatest loss potential in a particular process. It also enables one to predict the physical damage that would occur in the event of an incident. This popular safety best-seller is designed to help the user quantify the expected damage of potential fire and explosion incidents in realistic terms

- Fault tree analysis (FTA)

FTA is a common tool using graphics and statistics to analyze an event and predict how and how often it will fail. Used in engineering and business to aid process and system development. It is an effective way to diagram problems in a system; it will also help to organize possible causes of a problem in the system. There are three main

events which include: primary event, intermediate event, expanded event. Generally, FTA will prevent the error in the first place, after the error in the tire was found, finding all the things that caused it and prevent similar problems from happening again.

- Health, Safe and Environment Management System

Health, Safe and Environment Management is simplified as HSE. HSE is often used as the name of a department in corporations and government agencies. Companies that aspire to be better environmental stewards invest in strong environmental, health and safety management. From an environmental standpoint, it involves creating a systematic approach to managing waste, complying with environmental regulations, or reducing the company's carbon footprint. Successful HSE programs also include measures to address ergonomics, air quality, and other aspects of workplace safety that could affect the health and well-being of employees.

HSE consist of seven relevant factors below:

a. Leadership and promise

Leadership level promises that HSE is the inseparable part of system. It will be considered into events agenda of company. Promise provides necessary resources to ensure HSE management effectively. Also, achieve the gold of "Non-accidence".

b. Strategic Target

HSE is the union responsibility of management level, entire employee and contractors. Companies must set targets and make agreement with all stakeholders.

c. Resources and Documentary system

HSE management is the management of all membership in the company. Companies are responsible for dividing institutions, clear and definite responsibilities, also personalize it. It includes: duty, resource, ability, information, community, document and control.

d. Judgment and Risk management

Judgment is the foundation of establishing and executing HSE management. It will figure out the potential of health, safe and environment, then summarize from historical HSE management which including harm, affection, establishing standard of judgment, and risk decreasing.

e. Planning

In order to achieving goals, planning has to through the matters of several aspects below: facility complete, responsibility, working process, emergency solving, judgment and continually update. It will include general regulation.

f. Implement and Monitor

Companies have to follow the rules of HSE to execute activities which means the

judgment of potential harm of activity, set specific target, risk decreasing, human resource, facilities and financial support, emergency solving. Also, activity and task, monitor and record, report of accident and followed up included. Here, monitor is the key role of HSE management system, it is the sum up of supervising, inspecting, analyzing and so on.

g. Examine and Review

Examine is the judgment activity of whether the system followed up the plan and whether the company meet the requirement of HSE management system. The top manager of the company will judge the entire HSE management system in order to promote suitability, sufficiency and efficiency. The final goal is to continually increasing HSE management system.

## **Chapter Three: Safety culture**

### **3.1 Culture**

The safety culture of an organization plays an important role in effective risk management of an organization. The safety culture creates the environment in which the workers of an industry operate. When it comes to nuclear power station, the culture influences how the crew and managers of a nuclear power station operation interact. It is important to understand the influences that are affecting the environment and the safety culture within which people work.

#### **3.1.1 Defining the different aspects of culture**

Culture surrounds us and influences the values, beliefs, and behaviors that we share with other members of groups. Culture connects people together and to provide clues and cues as to guide our behaviors and thinking. In thinking of culture, what comes to mind first is national culture, the attributes that differentiate between natives of one culture and those of another. There are three cultures can shape actions and attitudes. The first, of course, is national culture. The second is strong professional culture that is associated with education background and working experience. Finally, organizations have their own cultures that are closest to the daily activities of their members. While national cultures are extreme difficult to change because they surround an individual from birth, professional and organizational cultures may be changed if there are strong incentives.

##### **(1) National culture**

National culture represents the commonly shared aspects of national features. These include behavioral norms, attitudes, and values. Some aspects of national culture that have been identified are as a national symbol. For example, Japanese have a stronger sense of time, German people are rigorous on working process, Chinese people advocate collectivism, the United States much respect heroism and individualism.

##### **(2) Professional Culture**

In strong professional industry, a very positive aspect of the culture of operators is pride in their profession. They love their jobs and have strong initiative to do it well. This can help organizations to improve safety and efficiency, reduce human errors in operations.

##### **(3) Organizational culture**

Organizational culture is as a shell; contain the part of the national culture and professional culture, but not all of them. Organizational culture decides the workers' behavior norm and thought. At the organizational level, a good organizational culture can create and nourish a good safety culture, which includes senior managers' commitment, encouraging open communication and action.

### **3.2 Safety culture**

The term safety culture was introduced by the International Atomic Energy Agency (IAEA) as a result of their first analysis into the nuclear reactor accident at Chernobyl (Lee, 1998). In the accident of nuclear leak, a series of errors and violations of the operating procedures caused this serious disaster in nuclear industry. And the accident was considered as powerful evidence of a poor safety culture at the equipment. From then on, safety culture was regarded as an important safety factor which can contribute accidents. And Chernobyl accident led to set off a lot of research and investigation to measure safety culture in many high risk industries.

The concept of safety culture has been defined many times in different approaches. Searching the definition from internet, the definition from the Advisory Committee on the Safety of Nuclear Installations (ACSNI) seems to be cited with high frequency. Here, 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, an organization's health and safety management (ACSNI, 1993). Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures (ACSNI, 1993). Actually, like other definitions of safety culture, these definitions are widely used, and they originated mostly from theory, rather than empirical measurement.

Most of the researches have tried to measure safety culture, positive safety attitudes are considered as the most important part of good safety culture. In 1983, Zohar attempted to measure of safety culture, and expounded what safety climate in 20 Israeli industrial organizations. Zohar's conclusion is that employees share about their work environment and more specifically, this climate employees perceptions about the relative importance of safe conduct in their occupational behavior (Zohar, D., 1980). Zohar's measure includes eight dimensions (Zohar, D., 1980): (1) safety training; (2) required work pace on safety; (3) organizational status of safety committee; 4) organizational status of safety officer; 5) effects of safe conduct on promotion; 6) level of risk at the workplace; 7) safety management attitudes and 8) Effect of safe conduct on social status.

### **3.3 Commonalities on safety culture**

National Culture, Professional Culture, and Organizational Culture all have major influences on an organization's safety culture (Wiegmann,et,al.,2002). Through a comprehensive study of safety culture and from the various definitions, found several commonalities that exist regardless of the industry being considered.

These commonalities are:

- Safety culture is a concept defined at the group level or higher, which refers to the shared values among all the group or organization members;
- Safety culture is concerned with formal safety issues in an organization, and closely related to, but not restricted to, the management and supervisory systems;
- Safety culture emphasizes the contribution from everyone at every level of an organization;
- The safety culture of an organization has an impact on its members' behavior at work;
- Safety culture is usually reflected in the contingency between reward systems and safety performance;
- Safety culture is reflected in an organization's willingness to develop and learn from errors, incidents, and accidents; and
- Safety culture is relatively enduring, stable and resistant to change.

### **3.4 Safety culture and safety climate**

There is a demand to differentiate definition of safety culture and safety climate. First of all, the two words seem some certain degree of overlap in meanings and understanding, but the focus is not the same. In the meaning of safety culture mainly reflects that safety attitudes, safety conceptions and values that workers own on related working and assignments. In the meaning of safety climate mainly reflects that a set of safety conceptions and values had by an organization or a group.

In an organization, safety culture is considered as basic safety belief of organization which is determined by this organizational value, norm and rule. Safety climate is considered as the state of an organization in term of organizational safety perception, norm and rule in current environment. Accordingly, it can be said that workers own a safety culture in a working place with a safety climate.

### **3.5 Outstanding representation of safety culture**

Safety culture is usually referred to as a "safe climate", in a nutshell, the outstanding representations of a good safety culture include following three aspects:

- (1) A good communication mechanism on the safe operation of good practice and lessons from the accidents between all of the internal departments in organization. Specific representation as to whether the lessons from accidents are conveyed and learned timely, effectively; to whether a good safety management manner are promoted timely; to whether a bad or unsafe working behavior are restrained and corrected.
- (2) An organization with good safety culture should form harmonious sharing experience and safety knowledge promotion. Specific representation as to whether every drilling worker and manager own accident-free safety goal; to whether everyone can frankly point out advantages or shortcomings of others' working behaviors; to whether safe working has been become a conscious and spontaneous desire; to whether safe operation has been become the basic quality of personnel and employment prerequisite.

- (3) Organizational personnel whether have enough emphasis degree on safe operation, whether own necessary safe skills and ability of risk identification.

### **3.6 Safety Culture Maturity Model**

#### **3.6.1 The demand for a safety culture model**

Many facts have proved that a close relationship between an excellent safety culture and good safety performance, so many high-risk organizations attempted to evaluate their current safety culture, and identify advantages and parts of improvement needed.

In Europe and some developed countries, especially in offshore oil and gas exploration industry, survey concerned with safety culture have acquired varying degrees of success, and a modern-day organization's safety culture model have been built, namely, Safety Culture Maturity Model (SCMM). This model has been widely tested; the testing crowd mainly came from safety engineering experts, safety managers and on-site workers. The led to the definition of a Safety Culture Maturity Model, with five levels of maturity (described below) and ten elements, namely (Fleming et al, 1999):

- Visible management commitment
- Safety communication
- Productivity versus safety
- Learning organization
- Health and safety resources
- Participation in safety
- Shared perceptions about safety
- Trust between management and frontline staff
- Industrial relations and job satisfaction
- Safety training

#### **3.6.2 Assumptions of the safety cultural maturity model**

Cultural or behavioral ways are considered as the most effective in safety improvement, when the safe technical and safe designed aspects are reliable and the majority of accidents attributed into behavioral or cultural factors. The safety culture maturity model is therefore only of relevance to organizations that fulfill a number of specific criteria, these include (Fleming et al, 1999):

- An adequate safety management system
- Technical failures are not causing the majority of accidents
- The company is compliant with health and safety law
- Safety is not driven by the avoidance of prosecution but by the desire to prevent accidents.

If an organization does not meet these criteria then it would be more appropriate for them to focus their resources on the technical and systems aspects of safety as opposed to the behavioral and cultural aspects.

### 3.6.3 Five levels of safety culture maturity

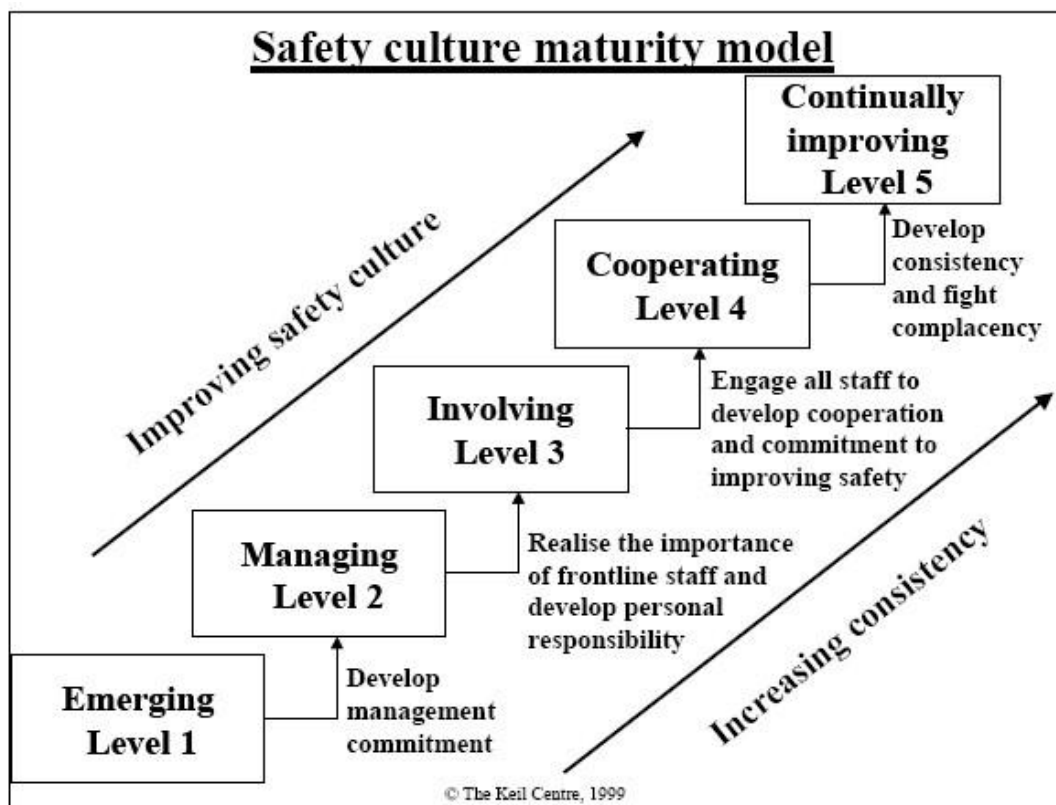


Figure 4: Safety culture maturity model (Fleming et al, 1999)

#### Level One: Emerging

The prominent feature on this level

- Basic safety regulation of the organization and the system is complete or are being developed;
- The understanding for safety, only represent on working procedures and safety skills;
- Compliance with the relevant standards, laws and regulations;
- Safety issues have not been understood as the organization's primary problem, in employees' awareness, the need for safety only is solved by safety department or safety supervisor, rather than each working department;
- Operating personnel for attitude of accident which is inevitable in the working process.
- Operating personnel has a positive attitude on safety management, but essential safety only is a concept or an excuse.

#### Level Two: Managing

The prominent feature on this level

- The organization's accident rate is average for its industry, or slightly higher than average;
- Operating personnel for attitude of accident which is prevented in the working process;



- Safety is only defined in term of compliance to rules and procedures and engineering requirement;
- Safety managers can perceive that the most of accidents are caused by the unsafe behavior of on-site operating personnel;
- Safety performance is measured in term of relevant indicators
- Organizational operating personnel can accept safe training and education;
- Safety incentives are based on reduced accident rate;

### **Level Three: Involving**

The prominent feature on this level

- Organization has a low accident rate in its industry, and the rate is very steady;
- Managers perceive that management decision is a important factor that maybe root cause of accident;
- A considerable proportion of on-site operating personnel are willing to join into safety management and improve health and safety;
- The most of organizational personnel accept personal responsibility for their own health and safety;
- Safety performance is actively monitored and the data is used effectively;
- Active participation in safety and health from on-site operating personnel is an important factor to improve safety performance;

### **Level Four: Cooperating**

The prominent feature on this level

- The most of organizational personnel believe that health and safety is important from both a moral and economic point of view.
- On-site operating personnel and managers perceive that management decision is a important factor that maybe root cause of accident;
- The most of on-site operating personnel accept personal responsibility for their own health and safety;
- The organization makes significant efforts into proactive measures to prevent accidents;
- Operating personnel's values and fair treatment, which is considered to be important by organization;
- Safety performance is actively monitored using all data available.
- Non-work accidents are also monitored and a healthy lifestyle is promoted.

### **Level Five: Continuous improvement**

- The prevention of all injuries or harm to employees (both at work and at home) is an organizational core value;
- The organization has had a persistent period without a recordable accident or potential incident, but there is no feeling of complacency;
- Safety managers recognize that safety control is sustained, if they treat safety lightly, accident just around the corner;
- The organization applies a series of indicators to monitor safety performance but it

is not performance-driven, because it has enough ability to control its safety processes; The organization is constantly striving to be better and find better ways to improving risk control mechanisms;

- All personnel believe that health and safety is critical;
- All personnel accept that the prevention of non-work injuries is important;
- The organization invests considerable cost on promoting health and safety;

### **3.7 Hudson's safety culture model**

Westrum (cited in Westrum & Adamski, 1999) suggests that the critical feature of organizational culture is information flow. Hudson (2001) further developed this work by defining five distinct climates that define stages of an organizations safety culture. These five stages are (Hudson,P.,2001):

#### **(1) Pathological:**

The organization cares less about safety than about not being caught;

#### **(2) Reactive:**

The organization looks for fixes to accidents and incidents after they happen;

#### **(3) Calculative:**

The organization has systems in place to manage hazards; however the system is applied mechanically. Staff and management follow the procedures but do not necessarily believe those procedures are critically important to their jobs or the operation;

#### **(4) Proactive**

The organization has systems in place to manage hazards and staff and management have begun to acquire beliefs that safety is genuinely worthwhile;

#### **(5) Generative**

Safety behavior is fully integrated into everything the organization does. The value system associated with safety and safe working is fully internalized as beliefs.

These five stages provide a model for measuring the maturity of an organizations safety culture, and the following table 1 can show measuring items.

Table 1: Descriptions of the different types of safety culture (Hudson,P.,2001)

	<b>Pathological</b>	<b>Reactive</b>	<b>Calculative</b>	<b>Proactive</b>	<b>Generative</b>
<b>COMMUNICATION</b>	Nobody is informed, no feedback, everybody is passive, no care/knowledge about safety, don't see(k) or ask the problem, collect what is legally required	Management demand data on HSE failures, denial until forced to admit, top-down flow of information, bottom-up incidents, lots of statistics nobody understands, safety hot issue after accident	Environment of command and control by management, lots of HSE graphs, statistics but no follow up, info goes top-down, failures bottom-up, little top-down feedback, toolbox meetings, procedures exist but are only once read. Action is delayed after knowledge	Management goes out and seek, discuss for themselves they know what to change and how to manage, the feedback loop (bottom-up and top-down) is closing at supervisory level, safety topics become part of other meetings, asked for by workforce, they need detail to understand WHY accidents happen	No threshold between management-workforce, management participates/shares activities (dialogue), HSE is number 1, all feedback loops are closed, safety is integrated in other meetings; no special safety meetings required, workforce keeps itself up-to-date, they demand information so they can prevent problems
<b>ORGANIZATIONAL ATTITUDES</b>	No belief or trust, environment of punishing, blaming and controlling the workforce	Failures cause by individuals. No blame but responsibility, workforce needs to be educated and follow the procedures, management overacts in eyes of workforce	Workforce is more involved, little effect on procedures, designs, practices. Workforce does not understand the problem, management is seen as obsessive with HSE, but they don't 'mean' it (Walk-talk)	Workforce involvement is promoted but rules/organized by supervisory staff which is obsessed by HSE statistics	Management is recognized as a partner by workforce, management respects workforce, management has to fix systematic failures, workforce has to identify them.

<b>HEALTH, SAFETY AND ENVIRONMENT (HSE)</b>	No HSE status, HSE issues are ignored, minimal requirements, no rewards on good performance, safety is inherited but not known, reliance on experience	Meets legal requirements, collects statistics but no follow-up, design is changes after accidents, procedures are rewritten to prevent previous accidents, no update or improvement.	HSE well accepted, advisor collects data and creates own statistics, HSE rewards for positive and negative performance, design: quantitative methods, procedures to solve unsolved problems, standard procedures preferred from the shelf, large numbers of procedures but few checks on use/knowledge.	Separate line HSE advisors promoting improvement, but try to reduce the inconvenience to line, for good HSE initiatives there is career enhancement for senior staff, HSE is in the early stages of design, procedures are rewritten by workforce, integration with competency, complaints about externally set targets.	HSE department is small, advising the management on strategy, group, no special rewards, individual pride, procedures are written by workforce, continuous improvement, small numbers of procedures are integrated in training.
<b>ORGANIZATIONAL BEHAVIOUR</b>	Denial anything is wrong, avoids HSE discussion, management is hierarchical and stagnant to changes, focus on profits not on workforce, workforce has lots of freedom as management don't care	Management holds workforce responsible for failures, overacting, management states that it takes safety seriously, but it is not always believed by workforce.	Detail focused/playing with numbers, believe company is doing well in spite of contrary, targets are not challenged, inability to admit solutions may not work the first time	Management knows the risks, interested in HSE, takes culture into account, safety priority over production which leads to incompatible goals, lots of management walk-about, communication and assessment about accidents and near misses and their consequences	Safety is equal to production, enthusiastic communication between workforce and management and vice versa, workforce has a lot of freedom due to trust.
<b>WORKING BEHAVIOUR</b>	Workplace is dangerous, messy, no (legal) health requirements, management does not CARE and does not KNOW.	Basic legal requirements implemented, housekeeping is temporary, improved when inspection comes, management KNOWS but does not always CARE.	Clean and tidy working environment, housekeeping is very important (prizes). Management CARES but does not always KNOW.	Management CARES and KNOWS, discussion about prioritization, time and resources are available for improvements even before accidents happen.	Management CARES and KNOWS, workforce furnishes its own environment, management passes the experience around to other sites.

## **Chapter Four: Identify safety culture aspects in drilling rigs with international working environment**

Drilling rig safety culture is not isolated; it could not be separated from the drilling company's safety concept and leadership's safety attitude to identify a drilling rig's safety culture. Try to imagine, if a drilling rig has an excellent safety culture, this drilling company would also have equally as excellent safety culture. Similarly, if a drilling company has a poor safety culture, its drilling rigs could not deliver excellent safety performance, because the company is not able to provide the necessary resources and information for its drilling rigs. Before identifying drilling rig safety culture, first of all, drilling company's safety culture should be identified.

In this chapter, by analyzing the different drilling companies HSE concept, safety performance, training, incentive, equipment selection and case study to identify drilling company's safety culture and rig's safety culture.

### **4.1 Identify safety culture in different drilling companies**

Both Transocean and Diamond Offshore drilling company are the world top 10 drilling contractors, they have abundant drilling experience, and have good reputation in drilling industry. Most of their drilling rigs are working in the deep and ultra-deep water area, their transactions distribute all over the world. They are able to manage so many drilling units, and work in challenging environment, while they have good safety performance, so chose them as researching, analysis their safety management and safety concepts to identify drilling company's safety culture.

#### **4.1.1 Introduction on Transocean**

Transocean is the world's largest offshore drilling contractor, they have versatile mobile drilling units, and desire to help their customers to find and develop oil and natural gas in the deep waters and harsh environments of various water depths. More than 50 years drilling experience and high specification rigs can show their strong competition. Transocean's drilling services cover the all over the world, the market includes the U.S. Gulf of Mexico and eastern Canada, Brazil, the U.K. and Norwegian sectors of the North Sea, West Africa, Asia, Australia, and the Middle East, Saudi Arabia, India and the Mediterranean.

#### **4.1.2 Identify Transocean's company safety culture**

##### **QHSE concept in Transocean**

Transocean's QHSE policies are systematic regulations, and all contents built surround their goals, and to support their efforts to achieve this goal. "All of our actions will be guided by our FIRST Core Values – Financial Discipline, Integrity and

Honesty, Respect, Safety and Technical Leadership. We will conduct our operations in an incident-free workplace, all the time, everywhere” (source: <http://www.deepwater.com/fw/main/Health-and-Safety-Policy-Statement-562.html>).

Transocean has current mainstream core values, integrity, safety, respect and technology. For safety and the environment, Transocean has a responsible attitude for society; take the initiative to limit the adverse effects of the transaction, to prevent environmental pollution. And company's goals and transaction is a periodic improving process, it focus on production safety and environment; respect the laws and regulations of the industry.

The fundamental expectations within their QHSE management system are (source: <http://www.deepwater.com/fw/main/Health-and-Safety-Policy-Statement-562.html>):

- We will work in a safe and environmentally responsible manner.
- We will comply with our Company Management System and all applicable laws and regulations at all times.
- We will conform to agree customer requirements.
- We will promote and maintain service quality and facilitate continuous improvement within each business process.
- We will regularly establish and review objectives as part of our continuous improvement effort.
- We will participate in developing action plans using Company approved processes.
- We will participate in our START and THINK processes, and call a "Time Out for Safety" when necessary.
- We will report and respond to all incidents of any kind.
- We will conduct our business to limit adverse impact to the environment and prevent pollution.

### **Health in Transocean**

Transocean has an excellent concept of health, and also has a very complete occupational health program to control and deal with unexpected accidents. Transocean is committed to minimize risk exposure on their employees’ health during their assignment and contributing to a healthier life when at home with families through active preventive initiatives, company provides necessary resources and information to prevent occupational disease, so that the concept can be truly achieved. Transocean not only concerned with the occupational health in working time, but also to promote healthy lifestyle in no-working time. Health is like a coin with two sides, medical and occupational health.

#### **(1) In medical health**

Transocean has pro-active health management as reflected through building complete medical health system and some programs to promise in their commitments. They offer the following (source: [www.deepwater.com/fw/main/Health-561.html](http://www.deepwater.com/fw/main/Health-561.html)):

- Medtrack Program
- Malaria Control Plan
- Offshore Medical Resources
- Topside Medical Support
- Worldwide Medical Assistance
- Healthy lifestyles – fit to work, health promotion, wellness

Medtrack Program can offer complete periodical medical examinations, and include the personnel deployed or traveling overseas as well as the immunization program and the Malaria control Plan. In addition, based on their own offshore resources, Transocean has built good cooperating relationship and transaction in local medical providers to offer timely and effective medical resource in any medical situation occurring in anywhere.

## **(2) In occupational Health**

In Transocean, they treat occupational health in the same grade as safety. They consider that most of occupational health and safety hazards are caused by energy sources which can cause harm to their employees. To eliminate these hazards, first of all, they can identify energy sources that can result in unplanned or unexpected energy releases. Then they can manage these occupational health hazards by assessing the risks and taking preventive actions. For promising to achieve this aim, occupational health policies and procedures are built to prevent these unnecessary risks. In fact, some known risks exist in working environment, such as noise, are identified to prevent in this industry. However, in Transocean, there is not enough, or nothing be done to relief an occupational health problem. Based on understanding the potential for health risks, Transocean made effective preventive measures to control and eliminate occupational toward incident free operation. Identified potential factors of health risk include noise, vibration, ergonomics and respiratory.

### **Environment in Transocean**

Transocean has very good concept of environment protection "first for the environment". And investment on energy conservation and waste management, and it has the most up-to-date systems and procedure in environmental protection.

The following description is "first for the environment" concept (source: <http://www.deepwater.com/fw/main/Environment-81.html>):

- Financial Discipline – Our investment in energy conservation and waste management will reduce our environmental footprint while saving money and wear on equipment.
- Integrity and Honesty – We will report and investigate any environmental incidents openly and honestly.
- Respect – We have a profound respect for the environment in which we work each day.
- Safety – Safeguarding people, property and the environment around us is paramount.

- Technical Leadership – Our use of the most up-to-date systems and procedures will ensure environmental protection and continued good stewardship.

At Transocean, they use their global environmental management system to achieve environment responsibility every day, and link their external stakeholders to make efforts on environment protection.

### **Safety in Transocean**

"Our operations will be conducted in an incident-free workplace, all the time, and everywhere" is Transocean's safety concept (source: <http://www.deepwater.com/fw/main/Safety-560.html>); company makes efforts to achieve this goal with more than 21,000 employees, spanning 20-plus countries, with numerous nationalities and cultures. And in the past, Transocean has good history of safety management, had an incident frequency rate of 28.93 incidents per 200,000 hours worked. For accomplishing this goal, company developed comprehensive training and mentoring programs to complement their innovative safety tools and processes.

At Transocean, they firmly believe that the safety of people underpins our success. This safety vision covers all drilling units and shore-based facilities worldwide. In Transocean's website, they proudly show their excellent record. In 1958, the Offshore Company, a predecessor of Transocean, created an incident frequency rate of 28.93 incidents per 200,000 hours worked, which at that time was considered an important safety milestone. Facing modern more complex operational challenges and deepwater harsh environment, Transocean achieved total recordable incident rates below 1.00.

To continue good safety tradition, Transocean has developed complete training and monitoring programs to create much better safety situation, and complement their innovative safety tools and processes. After all, they always think that an incident-free workplace does not come through a focus solely on safety, but from all the elements of QHSE and most importantly from their people (source: <http://www.deepwater.com/fw/main/Safety-560.html>).

### **Recruitment condition in Transocean**

In new employee recruitment, Transocean much concern with new employee's past working experience, and working skills, previous operational experience on a semi or drillship would be preferred. Education background is required, in recruitment condition, showing the detail requirements. A good recruitment mechanism can bring positive effect in company's safety performance and assignment. In the contrary, if company recruitment some employees who had bad safety record and weak safety awareness, their unsafe behaviors or instructions will bring risks for themselves or their colleagues, even break or weaken safety climate of drilling rigs. The following description which is from recruitment website is Transocean toolpusher's recruitment condition (source: <http://www.subsea.org/jobs/jobdescription.asp?job=1623>)



If you can live up to Transocean's core values and meet these requirements we would like to hear from you. 1. Knowledge and supervision of the drilling operations and associated activities in accordance with the well program. 2. A high school diploma or equivalent with at least 8 years of relevant work experience. 3. To provide leadership to rig personnel and assist in training to ensure staff perform competently on their respective positions. 4. Monitor the maintenance, repair and installation of all drilling equipment including repair, lubrication, maintenance records and inventory levels. 5. Ensure that the mud mixing systems and solid control equipment are monitored and properly maintained. 6. Ensure a high standard of hygiene and housekeeping are maintained on the rig. 7. Previous operational experience on a Semi or Drillship would be preferred. 8. Candidates must be willing to work internationally on a 28/28 rotation.

### **Drilling equipment improvement and update in Transocean**

For adapting market demands and deepwater operating environment, Transocean selected many advanced equipment, these equipment utilized can effectively promote safety and reliability of equipment and enhance drillship operating capacity. In operation, new technology was designed to save non-production time and drilling costs in deepwater well construction compared with conventional rigs, at same time, new equipment applied can reduce operating and repair risk, and to provide more humanized designs to reduce maintenance operation and maintenance repair.

In 2006, Transocean constructed three enhanced enterprise class drillships at Daewoo Shipbuilding. In these constructions, some new type drilling equipment was installed and new technology was used.

The following table 2 shows new equipment and technology applied, their functions, as well as advantages:

Table 2: new equipment and technology applied in Transocean drilling rig

	<b>New drilling equipment or new technology</b>	<b>Function</b>	<b>Advantages</b>
1	Patented dual-activity drilling technology	Parallel drilling operation	Save time and drilling costs in deepwater well construction
2	Enhanced top drive system, an expanded high-pressure mud pump system	Target in drilling depth up to 40000ft	Enhanced drilling capability
3	Two complete BOP stacks, lower marine riser packages and pods	Cross-operation	Save time on testing and running the BOP and riser
4	Greater tree-handling capabilities	Store much more pipes in the rig	Save time during completions operations

5	latest drilling cuttings management technology	Provide sufficient storage capacity	Reducing non-productive time
6	robust components installed on top drive	Reduce maintenance and unscheduled maintenance	Reduce downtime
7	New power-management system	provide sufficient power	reduce the risk of power blackouts

### Training in Transocean

Transocean's safety concept is to create a no-accident workplace, anytime, in anywhere. They make efforts to attendees at the school to provide accident prevention tools, Transocean's commitment as well as HSE regulations. All new employees recruited are required to attend these courses prior as their first assignment in offshore.

Transocean's training almost covers all safety skill which is needed in drilling rig, at same time; company can provide some trainings related life and familial health aspects, for example, fall protection.

The following table can show Transocean's training programs (source: [www.deepwater.com/fw/main/TOPS-School-229.html](http://www.deepwater.com/fw/main/TOPS-School-229.html)):

- |  |
|--|
| <ul style="list-style-type: none"> <li>● The Company's Core Values</li> <li>● Determining your Colors (personality type)</li> <li>● The HSE Management System (THINK Plan and START process)</li> <li>● Fall Protection</li> <li>● Hazardous Communication</li> <li>● First Aid and Lifting Techniques</li> <li>● Rig Skills and Hand/Power Tools</li> <li>● Permit to Work &amp; Confined Space Entry</li> <li>● Helicopter Safety</li> <li>● Accident Prevention, The Cause &amp; Cure (Changing Behavior)</li> <li>● Getting ahead at Transocean</li> <li>● Water Survival &amp; Helicopter Underwater Escape Training</li> <li>● Fire Fighting Training</li> </ul> |
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Transocean owns a bonus plan, and uses bonus payout to motivate safety performance. The Executive Compensation Committee of Transocean evaluates and measures the safety performance with the TRIR and TPSR. Take Transocean bonus plan as example to mention its motivation mechanism.

#### (1) Performance Measures

The results of the three key performances need to be identified below, which were specified at the beginning of the year:

- Safety Performance, which was 25% of the total target bonus amount, with potential payouts ranging from 0% to 50% of the total target bonus amount based on actual performance. Safety performance is measured by:
  - Total Recordable Incident Rate (“TRIR”), which made up half of the Safety Performance metric; and
  - Total Potential Severity Rate (“TPSR”), which made up half of the Safety Performance metric.
  
- Financial Performance, which was 50% of the total target bonus amount, with potential payouts ranging from 0% to 100% of the total target bonus amount based on actual performance. Financial Performance was measured by Cash Flow Value Added (“CFVA”) relative to our annual budget.
  
- Strategic Corporate Objectives in the areas of execution, customer focus and people focus which were 25% of the total target bonus amount, with potential payouts ranging from 0% to 50% of the total target bonus amount based on actual performance. The business involves numerous operating hazards, and they are strongly committed to protecting their employees, their property and the environment. This ultimate goal is expressed in our safety vision of “an incident-free workplace—all the time, everywhere.” The safety performance targets for 2012 were approved by the Executive Compensation Committee and are set at levels each year that motivate their employees to achieve continuous improvement in safety performance and to meet strict internal standards.

Safety performance targets are recommended to the Executive Compensation Committee by the Board’s Health Safety and Environment Committee.

The Executive Compensation Committee measures safety performance through a combination of our TRIR and TPSR, and each component makes up half of the overall safety performance metric.

**(2) Total Recordable Incident Rate**

TRIR is a safety performance metric recognized by the U.S. Occupational Safety & Health Administration and is used by companies across an array of different industries. Transocean calculates TRIR based upon the guidelines set forth by the International Association of Drilling Contractors (the “IADC”), an industry group for the drilling industry. The IADC methodology calculates TRIR by taking the aggregate number of occurrences of work related injuries or illnesses that result in any of the following: (1) death, (2) a physician or licensed health care professional recommending days away from work due to the injury or illness, (3) an employee not being able to perform all of his or her routine job functions (but not resulting in days away from work), or (4) any other medical care or treatment beyond minor first aid.

The Executive Compensation Committee approved a TRIR target calculated as a

straight-line basis, which would represent further progress toward Transocean’s safety vision.

TRIR Outcome In Relation to Target	Bonus Payout Result for TRIR
20% Improvement Exceeding Target . . . . .	200%
10% Improvement Exceeding Target . . . . .	150%
Target . . . . .	100%
10% Shortfall . . . . .	75%
20% Shortfall . . . . .	50%

**(3) Total Potential Severity Rate**

TPSR is an internally developed safety measure that Transocean utilizes to capture the potential severity of incidents over a period of time. TPSR is calculated by taking the sum of all potential severity values assigned to the incidents, multiplying that number by 200,000, then dividing that number by total employee hours worked. After the occurrence of an incident, the manager or managers responsible for the drilling unit or onshore facility where the incident took place complete an incident report that assigns a preliminary severity value to the incident. The Company also has an independent oversight and review process to evaluate and confirm the potential severity assigned to each incident. The severity value is derived by inputting data into their comprehensive severity calculator.

The Executive Compensation Committee approved a TPSR target calculated as a straight-line basis, which would represent further progress toward Transocean’s safety vision. This target is calculated in accordance with the chart below, with outcomes falling in between two boundaries interpolated on a straight-line basis:

TPSR Outcome In Relation to Target	Bonus Payout Result for TPSR
20% Improvement Exceeding Target . . . . .	200%
10% Improvement Exceeding Target . . . . .	150%
Target . . . . .	100%
10% Shortfall . . . . .	75%
20% Shortfall . . . . .	50%

Transocean connects bonus payout with safety performance to motivate most of employees and managers to focus on safety, and achieve company’s safety concept.

**4.1.3 Introduction on Diamond Offshore**

Diamond Offshore Drilling, Inc. (Diamond Offshore) can provide drilling services in petroleum and nature gas exploration, and it is a leader in deepwater drilling. Diamond Offshore’s fleet of offshore drilling rigs consists of thirty semisubmersibles, seven jack-ups, and one drillship. In addition, four ultra-deepwater drillships and two deepwater semisubmersibles are currently under construction (source: <http://www.diamondoffshore.com>). Its service concept is that assignment is to preponderate over customer’s expectation and continually build higher standard, as

well as Diamond Offshore assists its customers to make efforts on discovering and producing offshore petroleum resources in global area.

#### **4.1.4 Identify Diamond Offshore's company safety culture**

##### **HSE in Diamond Offshore**

The Diamond Offshore considers that its safety culture is the overriding safety culture, company owns safety performance and safety management is to make them confident. Diamond Offshore own a large number of professionals in drilling industry, this is basis to get success in this industry. Based on past history and reported data, Diamond Offshore think that they are able to achieve their company-wide commitment---Zero Incident Operations (ZIO). Achieving ZIO means that no one gets hurts, the environment remains pristine and all equipment operates safely. This safety concept is very attractive for drilling industry.

They do not only own a good safety concept, they also have some management and performance evaluation approaches to achieve their safety goal, such as Global Excellence Management System (GEMS) and Diamond scorecard. For the past few years their total recordable incident rates have declined to record lows, based on these good management measurements and approaches, they can assist them to finish their various HSE goals.

In order to improve safety situation, Diamond also develop DODI, Hands-Off Tool, JSAMS, JPS, Safety Leadership Training, Advances in Incident Investigation, Green Committee for Environmental Protection to help them identifying risk, targeting undesired behaviors for correction and encouraging desired behaviors, so that these safety measurements can help them protect their assets: their people, environment, and our equipment and foster a positive and professional safety culture in drilling rigs.

##### **(1) Zero Incident Operations (ZIO)**

At Diamond Offshore, the goal of achieving Zero Incident Operations (ZIO) dominates our actions anywhere in the world we operate. It has a definite self-positioning in drilling industry; the self-positioning is premier safety and efficient rig operations around the globe.

To the people of Diamond Offshore, safety is a skill, not a set of rules stored on a computer. Like any skill, safety requires commitment, patience, practice, and careful technique to be mastered. We believe ZIO can be achieved anywhere in the world we operate. They expect every person working on Diamond Offshore's drilling rigs to do what is right by making each task as safe as possible, or stop the job if it is not. "Achieving ZIO means that no one gets hurts, the environment remains pristine and all equipment operates safely. Our safety leadership is exemplified in the innovations and advances we have incorporated into our culture" (source: [http://www.diamondoffshore.com/zero-incident-operations-\(zio\)](http://www.diamondoffshore.com/zero-incident-operations-(zio))).

## (2) Global Excellence Management System (GEMS)

“Diamond Offshore is committed to perform at the highest possible level of operational integrity, while emphasizing exemplary performance in health, safety, environmental protection, and regulatory compliance” (source: [http://www.diamondoffshore.com/global-excellence-management-system-\(gems\)](http://www.diamondoffshore.com/global-excellence-management-system-(gems))). To achieve these goals, Diamond Offshore builds Global Excellence Management System (GEMS), this system is a set of procedures to monitor, control and continuously improve performance in drilling operations. ZIO is as the driving force, and all the experience and creations they get is put into GEMS. GEMS is an integrated health, safety, environmental and quality system that outlines all of their policies and procedures to ensure that they satisfy customer expectations. Comprised of 13 shining elements, each named for a gemstone in recognition of its precious nature, GEMS sets the highest standards for operations around the world.

GEMS incorporates the elements of a safety management system with the recognized principles for quality management and includes the following:

GEMS CATEGORIES	
Pearl	Management leadership and commitment
Garnet	Risk assessment
Topaz	Personnel and training
Sapphire	Safety and environment
Ruby	Operations
Lapis	Maintenance
Amethyst	Audits and corrective actions
Emerald	Contract review
Turquoise	Third-party services
Onyx	Information and document control
Jade	Management of change
Opal	Customer satisfaction
Diamond	Diamond scorecard

Figure 5: the elements of a safety management system in Diamond Offshore (source: [http://www.diamondoffshore.com/global-excellence-management-system-\(gems\)](http://www.diamondoffshore.com/global-excellence-management-system-(gems)))

## (3) Diamond scorecard

Diamond scorecard is one kind of measuring approach; the key is to continuously improve various performance in their operations. Only through measurement can they evaluate their performance and assess their efforts to improve. Diamond Offshore

measures performance in all the key areas of safety, environmental responsibility, customer satisfaction, regulatory compliance, downtime management, and cost control. Diamond Offshore also promotes sharing culture, encourages the sharing of best practices, both among themselves and with other organizations. Based on sharing best practices, they can learn good ways, shift their old patterns, and constantly improve.

#### **(4) Behavior matters - DODI**

Diamond Offshore developed a kind of behavior-based safety program as a core element in the prevention of incidents. The Diligent Observation Decisive Intervention (DODI) process is established on the principle that is to correct unsafe behaviors and encouraging safe behaviors, the DODI can help Diamond Offshore protect their most valuable assets: their people, their environment, and their equipment.

Industry statistics show that about 90 percent of all incidents are directly related to undesired behaviors. The DODI Process helps eliminate undesired behaviors and helps foster a positive and professional safety culture in drilling rigs (Source: <http://www.diamondoffshore.com/safety-strategies/dodi-process-safety-program>).

#### **(5) Hands-off operations**

Diamond Offshore always pays attention on hand protection; it has a hands-off lifting policy and a dedicated hand safety committee that targets in eliminating hand injuries. The hand safety committee is comprised of managers and supervisors who work closely with on-site employees "in the trenches" situation to develop the effective tools and rules to eliminate hand injuries. "It is this combination of seasoned leadership and innovative personnel that has resulted in a dramatic reduction in hand injuries fleet-wide" (source: <http://www.diamondoffshore.com/safety-strategies/hand-safety-innovation>).

#### **(6) Environment**

Diamond Offshore is fully committed to preserving the environment with strict adherence to all applicable laws and industry recommended practices. As an industry leader in health, safety, and environment, they believe that all environmental incidents can be prevented by having the proper barriers in place (source: <http://www.diamondoffshore.com/environmental>). These barriers include adequate training, system policies, routine drills, environmental meetings, daily inspections, and corporate environmental audits.

Diamond Offshore also follows a rigorous maintenance program which ensures that machinery is operating at peak efficiency which in return helps reduce carbon emission. Diamond Offshore demonstrates environmental stewardship on a corporate level by participating in several industry and regulatory affairs meetings. This participation gives them the ability to proactively give input on how the industry is governed.

In onshore office, they strive to preserve the environment by participating in recycling and encouraging energy conservation. In addition, their employees and their families participate in the annual Texas Adopt-A-Beach Program and the Clean Galveston Program Walk-About (source: <http://www.diamondoffshore.com/environmental>).

### **Recruitment condition in Diamond Offshore**

Diamond offshore extremely concern with recruited employees' work experience, Recruitment condition shows detail job descriptions and responsibilities. Company requires recruited employees to have relevant professional skills and safety skills; they are able to provide valid certificates in professional and safety skills.

The following recruitment information is about Ballast Control Operator (source: <https://careers-diamondoffshore.icims.com/jobs/1027/job>):

#### **Ballast Control Operator Responsibilities:**

Operate ballast control system on a semi-submersible drilling rig to maintain the required stability of the vessel; continually monitor the deck loads so as to maintain the desired list/trim through activation of the proper stability procedures; responsible for performing tasks in a safe, conscientious, and efficient manner under the supervision of the Barge Engineer/Supervisor.

The Ballast Control Operator may be responsible for:

- Ballast and de-ballast the rig as required to maintain station.
- Monitor all ballast controls and related instrumentation.
- Monitor variable deck load on a daily basis to calculate and maintain the rig's stability.
- Prepare the daily and weekly stability report for the rig.
- Monitor quantities of expendables such as fuel, potable water, drill water and report findings to Barge Engineer/ Supervisor.
- Inform the Barge Engineer /Supervisor about any anomalies, which may affect the safe and efficient operation of the rig.
- Carry out Preventive Maintenance on ballast control equipment and other marine equipment as required.
- Inspect ballast equipment and other marine operations and lifesaving equipment, as required, for safe working conditions.
- Monitor the weather conditions and rig motion.
- Assist the Barge Engineer/ Supervisor in carrying out rig move plans, aid anchor handling boats, and perform mobilization and demobilization preparations.
- Follows Diamond Offshore Global Excellence Management System (G.E.M.S.).



Qualifications:

- At least 18 years of age
- Valid USCG Ballast Control Operator's License/Endorsement
- 1 or more years of direct experience as a Ballast Control Operator
- Ability to perform simple mathematical equations
- Possess or able to obtain a valid passport

Preferred

- Possess or able to obtain a valid Transportation Worker's Identification Card.
- Legally authorized to work in the United States without restrictions.
- Possess High School Diploma / GED or higher.
- 3 or more years of direct experience as a Ballast Control Operator.

### **Training in Diamond Offshore**

Diamond offshore has world-class and complete training programs; it can provide professional training, such as well control, stability and ballast control and crane operations. Training program tracks every employee's training history and monitors and updates that person's training; it is similar as an individual training file for every employee. Company can provide training simulators and training laboratories to promote employees' skills and understandings on drilling rig, and it is a reflection of the safety and training culture within the company.

#### **(1) Field position competency training**

In Diamond Offshore, it owns a worldwide competency program which can track every employee's training history and monitors and updates that person's training around the world. That means every employee's career path is on track and focused no matter where the employee is working, this can help their employees continue to improve and satisfy their long-term advancement goals.

#### **(2) Well control training laboratories**

Diamond Offshore can provide training laboratories where expert well control practices and procedures for their employees. "Fit for purpose" is company's training concept, these training laboratories can deliver hands-on experience and help on-site worker to develop critical thinking and problem-solving skills. As a founding member in the development of the Well CAP Training Program for the International Association of Drilling Contractors (source: <http://www.diamondoffshore.com/training-and-development-programs>), Diamond Offshore has developed a well control training program that aims on leading the industry in comprehensive well control training.

### **(3) Advanced ballast control simulator**

Diamond Offshore invests in available advanced training tools. Ballast control simulator is one of these tools. The simulator is same as operating system of drilling rig; the system can simulate virtually any combination of conditions pertaining to rig buoyancy and position, from wave action and weather to operational issues and emergency situations. The simulator's flexibility allows it to create any types of training; on-site employees can practice all operations they need in this simulator.

### **(4) Crane simulation and assessment**

Crane is one of key equipment in the deck of drilling rig, crane operating is also an important risk factor, and incorrect crane operation could cause serious incident. Aim on achieving safe crane operations, Diamond Offshore offers crane training and emergency operations for crane operators and deck coordinators together in full scale heavy crane lifts. A state-of-the-art crane simulator can record all operating data and assess team performance in training process.

#### **Lessons learned from reported incident in Diamond Offshore**

Accident is unacceptable by all, but the accident report is very valuable. From accident report, can get safety experience and lessons learned, and guide future safety work in the right direction. Larry Dickerson, president and CEO of Diamond Offshore Drilling much concern with reporting and lessons learned from reported incident, this mechanism have been implemented for several years in Diamond Offshore. At the 2013 IADC HSE & Training Conference in Houston, in his presentation, Mr. Dickerson said “Since 1979, the industry’s declining lost-time incidence (LTI) rate has reflected tremendous progress in safety, but at the same time it shows there’s much more to be done before reaching zero. As industry continues to move toward absolutely safe operations, reporting incidents – big and small – is key to achieve zero-incident operations, or ZIO. It’s very important that in any safety system you develop a culture of reporting anything that happens. ... We’re not going to achieve ZIO by not reporting.”

Mr. Dickerson definitely expresses incident reporting is an invaluable tool, not only to measure progress but also to support other safety initiatives based on lessons learned. Mr. Dickerson considered that learning incident report and reporting are one aspect of safety culture. They are benefit for achieving zero-incident operations.

“There is a fine balance between instilling a safety culture and making sure that reporting is taking place”, Mr. Dickerson stated “Risk is not tolerated, but on the same token, it must be reported. In a recent incident, for example, a relatively new employee climbed a handrail instead of getting a stepladder, and the person fell and broke his arm. “Had he fallen and not broken his arm, we would want to know about that as well. We need to report that it is a near-miss.”

### **Drilling equipment improvement and update in Diamond Offshore**

Diamond Offshore is similar as the Transocean company in equipment choice. For adapting market demands and deepwater operating environment, it selected many advanced equipment to save non-production time and drilling costs, at same time, new equipment applied can reduce operating and repair risk.

The following description is that Diamond Offshore invested to construct two jackup drilling rigs in 2007; the box shows them to install new equipment and design with high performance and high reliability.

In 2007, Diamond Offshore had 2 jackups under construction, the Ocean Shield at Keppel FELS in Singapore and the Ocean Scepter at Keppel AMFELS in Brownsville, Texas.

The rigs had a 70-ft cantilever reach with a significantly greater load capacity than other jackup designs with similar rated depths, according to Diamond Offshore, enabling the rigs to handle the heavier drill string and casing loads more efficiently. The rigs have 2 million-lb derricks with crown blocks rated at 2.12 million lbs. Traveling blocks and power swivel are also rated to 2 million lbs.

Additionally, each rig had an NOV HPS 2 million-lb capacity top drive drilling system. The rigs also had 2 million-lb drawworks with pipe-handling equipment that includes an NOV BR6 Bridge Racker pipe-handling system and hydraulic roughneck.

Additionally, the rig applied Tripsaver technology that also was installed on the Ocean Rover and Ocean Baroness during their upgrades. Tripsaver provides for offline capabilities to carry out multiple tasks without interrupting the primary drilling operations, including setting aside the BOP to save a trip in subsea tree installations and suspension of casing in the moonpool while running anchors.

Other offline capabilities included making up and laying down drill pipe during drilling operations; 1,500 kips of set back while in transit, allowing drill pipe make up and setback during rig moves; picking up drill pipe while drilling; preparing tools while drilling; and making up shoe, float collar and centralizers to casing joints. For deep drilling and the use of larger pipe and greater hydraulics required for development drilling, the Ocean Endeavor and Ocean Monarch was installed 4 2,200-hp mud pumps as well as a dedicated 1,700-hp pump for the riser to ensure

that heavy cuttings can be returned to the surface.

#### 4.1.5 Summary on what is good safety culture of company

Through analyzing and demonstrating Transocean and Diamond Offshore's safety culture of company, to build a table to show good elements of company safety culture.

1	Company top managers' attitude on safety management	Continuous improvement on risk control theory and methods, a large number of cost is invested on improving safety and health of employees' families, company do not satisfy with results recorded in long-term no accident and no serious near misses. Company also focus on employees' health and family health in no-working time, and provide necessary resources to achieve this concept.
2	Company's decision on choice of equipment performance and reliability	Choosing high reliability, high performance and safer drilling equipment. Depending on using situation, propose reasonable suggestions for improvement, taking into account the humanized design.
3	Human resource's recruitment conditions for new employees	On recruitment, showing detail requirement, concerning with employees' past working experience, and need to check official certificate. The employees' abilities and safety skills are as the most important considerations on recruitment. Establishing employees' safety performance files, and in regular interval, rewarding employees who contribute for safety performance.
4	Safety training from drilling company	Provide necessary skill training and safety training, and focus on result of training. Provide necessary resource to help the workers and managers can easily access safety information they need, they can get complete and professional occupational diseases, work-related injury insurance training.
5	Safety commitment at all levels	Complete and systematic commitment at all levels.
6	Learning mechanism on accident report	Rig's workers and managers initiatively organize to learn accident report, and in the platform team and departments to discuss and summarize the cause of the accident, they develop preventive measures, and are able to implement these measures in on-site work.
7	Incentive mechanism on safety	For confidence in the overall safety management process, company adopts a great variety of indicators to assess safety performance. Set some employee examples who contribute excellent safety performance, use honor and rewarding to infect

		more employees.
8	HSE	Company own current mainstream core values on safety, health and environment. Aiming on minimum injury or no injury. For safety and the environment, Drilling company should have a responsible attitude for society; take the initiative to limit the adverse effects of the transaction, to prevent environmental pollution. And company's goals and transaction is a periodic improving process, it focus on production safety and environment; respect the laws and regulations of the industry.

## 4.2 Identify safety culture in different drilling rigs

In some certain degree, a good drilling company with good safety management system and excellent safety culture do not absolutely deliver some rigs with good safety culture. It is depended on on-site managers' attitudes, workers' safety awareness and consciousness, rig regulations and monitoring system.

Though some incident reports and excellent safety management case to analyze and summarize elements of safety culture in drilling rig.

### 4.2.1 Case study

#### Case one: Fatal injury – Transocean Leader drilling rig

(1) Accident information

Type of incident: Crush injury. Fatality.

Business Unit: Northern Business Unit

Country: United Kingdom

Location of Incident: Transocean Leader working in Schiehallion Field

Date of Incident: 2nd March 2002

(2) Brief introduction on incident:

A crewmember of the semi-submersible drilling unit, Transocean Leader was fatally injured on Saturday 2nd March at approx. 11:00am.

The accident occurred during a routine lifting operation while offloading from the supply vessel Maersk Assister. The task was to lift a 43-foot basket on top of another (but dissimilar) basket in the riser storage area. Several attempts failed to land basket in right position. At some point on the final attempt, the deceased moved into the riser bay area. The basket slipped and the deceased was struck, suffering fatal injuries.

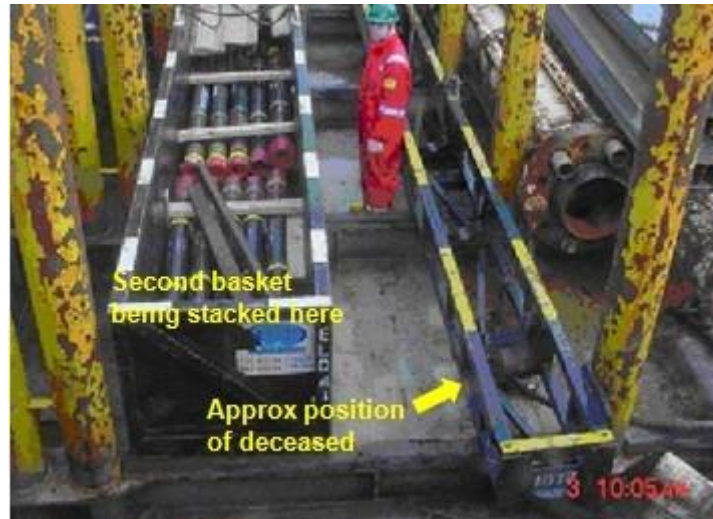


Figure 6: A basket on deck on top of which the 43-foot basket was to be landed. The deceased was found slumped over the basket on the right, close to the end. (The description is from "Man killed in oil rig accident". BBC News. Sunday, 3 March 2002. Retrieved 28 May 2010)

(3) Course of incident:

- Missed several opportunities to stop the job
- Deceased moved into a “caught between” situation
- Duties required of the Banksman
  - to stay clear of lifts
  - not get involved in handling
  - retain overview of the lift operation at all times
- Imbalanced load hanging unevenly, plus several failed attempts to land load, should have been identified as a management of change issue.

(4) Case Learned:

- On-site worker should have adequate risk identification, in operating; worker should pay attention to be correct position.
- Tools and cargo placed on the deck should be satisfied requirement of workplace management or rig safety regulation.
- All operations should be managed and monitored, so that risk could be controlled. More safety tips can prevent accident, reduce risk. When on-site workers find unsafe behaviors, they should stop as soon. (Crane operator could give safety tip to fatal personnel, or stop this dangerous behavior)

**Case two: Deepwater Horizon oil spill**

(1) Accident information

Type of incident: Spill oil, Hull sank, Explosion, Fatality.

Country: Gulf of Mexico

Facility: Deepwater Horizon

Operator: Transocean Ltd.

Date: 20 April, 2010

#### (2) Brief introduction in accident

The Deepwater Horizon oil spill (also referred to as the BP oil spill, the BP oil disaster, the Gulf of Mexico oil spill, and the Macondo blowout) was an oil spill in the Gulf of Mexico on the BP-operated Macondo Prospect, considered the largest accidental marine oil spill in the history of the petroleum industry. As more details emerge about the explosion and sinking of the Deepwater Horizon, which killed 11 workers and spilled millions of gallons of oil into the Gulf of Mexico, it has become clear that the single-minded drive for profit and a total lack of regulation created the disaster.

#### (3) Transocean's responsibilities for the accident

When well fluids escaped onto the drill deck and surrounding facilities. Emergency alarms and shut-down equipment and processes failed to function. The gas ignited resulting in two or more explosions that ultimately reached the drill deck—killing the eleven workers who were struggling to stop the blowout.

The Deepwater Horizon lost all primary power generation ability. Critical pieces of emergency control equipment were destroyed and damaged and could not be or were not activated. Emergency back-up power sources could not be started. The rig was in the dark, without power, and without the dynamic positioning thrusters to maintain its location.

The last defense against a blowout failed. The hydrocarbons reaching the surface ignited engulfing the Deepwater Horizon in flames. The emergency disconnection system meant to allow separation of the Deepwater Horizon from the blowout preventer at the sea floor could not be activated.

#### (4) Case Learned:

Emergency alarm, emergency equipment, emergency tool, well control equipment and tools should be available at any moment, and specialized crewmember to check and test before critical operation, or in regular interval.

### **Case three: Accident resulting in injury to a crew member working on the pipe deck**

#### (1) Accident information

Date: 20 July, 2010

Operator: Diamond Offshore General Company

Facility: Ocean Epoch

(2) Brief introduction in accident

Incident: A worker suffered a dislocated shoulder when he slipped and fell on an H-beam whilst working on the pipe deck.

Immediate cause: Slippery surface led to loss of footing.

(3) Cause of accident

Root causes: Procedures were incorrect, work direction – there was no supervision, design – management of change process requirement improvement.

(The description is from Statistics, trends and observations of the Australian offshore petroleum industry. Offshore Health And Safety Performance Report.

31.December.2011.)

(4) Case learned

- On-site managers and workers should have adequate ability to identify potential risk.
- Platform should improve rig safety regulation to complete aspect of workplace management; ensure a non-slip coating is applied to all trafficked surfaces.

**Case Four: Fatal accident with lifeboat on board platform “Ocean Ambassador”**

(1) Accident information:

Date: 17 May, 2010

Operator: Diamond Offshore General Company

Facility: Ocean Ambassador

(2) Brief introduction in accident

An exercise was in progress of the routine of launching the lifeboat on 17/05/2010. Lifeboat No.2 was lowered, with 4 people on board and placed in the water, without disconnecting the cables of the davit, by decision of the Offshore Installation Manager (OIM) concerned with the current. After the carrying out of the tests of the motor and the spraying system, which were considered satisfactory, the lifeboat hoisting was started back to the place of its stowage on board the platform.

Around one meter above the water the lifeboat hoisting was stopped for checking of the hooks, being executed by the crewmembers of the lifeboat and given as ready for restarting the hoisting. When the lifeboat was around two meters from the deck of stowage it had the hoisting again interrupted, this time due to the oscillations provoked by the rolling of the platform. That was when a loud noise was heard and the eyelet of



the cable of the davit, connected to the forward hook of the lifeboat release mechanism Triple 5 released itself, causing the lifeboat to take a vertical position being supported only by the after hook for some moments, when it also released the eyelet allowing the lifeboat to fall into the sea from an approximate height of 30 meters, turning over in the water and rolling about afterwards. The rescue boat was manned and lowered to rescue the lifeboat crewmembers victims of the accident.

The description is from Fatal accident with lifeboat on board the Platform “OCEAN AMBASSADOR”. Marine Safety Investigation Report. 17 MAY 2010.

(3) Cause of accident:

- Crewmembers mention the hydrostatic sensor and one of them mention the safety pin revealing ignorance of the functioning of the release mechanism.
- The personnel involved on the drill had not had training given by the manufacturer, which should occur by the fact that the device being new, different and unknown to the crewmembers;
- The crewmembers tend to generalize the functioning of the “hooks” which is interpreted as ignorance of the equipment in particular;
- One of the crewmembers directly in charge of the maintenance and operation of the release mechanism stated ignorance of the measurements and clearances established by Release Mechanism Operating & Maintenance Manual.

(4) Case learned

- On-site workers should have enough ability to safely achieve all required operations and maintenance.
- For new equipment, operators and maintenance crew should be trained before operation.
- Complete monitoring and supervising mechanism should cover all operations, for new equipment, managers should actively organize relate personnel to develop risk assessment, rather than blindly operating in unknown or unfamiliar equipment. Platform should have a complete risk assessment mechanism and risk management system.
- Continuously improve on-site workers safety awareness, skills and knowledge should be enhanced continuously by equipment or environment change, rather than completely depending on past experience.

**Case five: Fatal injury – Transocean Leader drilling rig**

(1) Accident information

Type of Incident: Body injury

Facility: Ocean Epoch

Operator: Diamond Offshore Ltd.

Date of Incident: 21.July.2007

## (2) Brief introduction in accident

The IP (personnel name) was in the process of fabricating some mounting plates from 3/4 inch thick steel plate. He had the steel plate secured on the drill press table where he had just completed drilling two pilot holes. In preparation to insert a larger drill bit, the IP was attempting to loosen the chuck with the chuck key to remove the pilot bit, when his foot inadvertently made contact with the foot operated pedal which started the machine. Due to the key being in the chuck and the IP holding it with a gloved hand, the key caught the glove as it rotated and pulled the IP's wrist and forearm around the spindle (chuck), resulting in an open compound fracture to the IP's forearm.

## (3) Investigation findings:

- The IP is an experienced tradesman of 20+ years with offshore experience.
- The IP had operated the drill press on numerous other occasions without incident and was familiar with its operation.
- The IP was fabricating mounting plates for the relocation of the fog horn.
- The IP was not under any pressure to complete the job, it was not urgent.
- At this time the IP was wearing leather welding gloves on both hands.
- As the IP was applying pressure to the chuck key to loosen it, he was distracted by a co-worker whom had entered the workshop to get a tool from his toolbox. They had brief communication in passing.

On re-enactment of the incident it was found that when applying pressure to the chuck key to loosen the chuck, the natural reaction of the body is to step forward with the left foot to gain better support.

It is believed that the IP had been distracted by his co-worker and simultaneously stepped forward while trying to loosen the chuck. As he stepped forward, his foot made momentary contact with the foot switch and, because the ES button was not engaged, the machine started. Due to the IP holding the chuck Key (with a gloved hand) in the chuck when the machine inadvertently started, the key pierced his glove, not allowing him to pull his hand away, which resulted in the IP's hand and forearm rotating around the chuck. Due to the drill press being gear driven, just a glancing touch of the pedal will initiate 3-1/4 revolutions of the chuck with no resistance on the bit.

At this point his co-worker was exiting the workshop and noticed the IP being pulled in to the machine from the corner of his eye. The co-workers instant reaction was to hit the ES button. The co-worker then called the other Welder for help and started to manually reverse rotate the machine to free the IP. The other welder noticed the seriousness of his injuries and immediately called for medical assistance.

## (4) Case learned

- Post operational instructions and warnings signs on machine.
- Ensure all operating functions are clearly labeled (Workplace management).

- Even though one worker has ten years no-accident record, he should not have loose attitude in working, because accident may occur in next minute. So any on-site worker should keep strong safety attitude at any moment. Promote safety awareness continuously, based on job content, build a correct working habit to reduce potential.

**Case six: Diamond Offshore Rig 650 celebrates 12 full years without an LTA**

The outstanding crews on Diamond Offshore Rig 650 have posted 12 years without a lost-time accident. Rig 650 reached the milestone 12-year mark on 10 Jan, 1999, but the men are moving ahead to set new records. The crews have been doing completion and work over, P&A, sidetracking, straight and horizontal drilling—all these different operations without an LTA.

The safety program which produced these remarkable results has several key elements, but 3 important ones are: enforcement of company policy and a personal safety action plan for each man. One factor which contributed to this milestone is that the rig worked for one client—Unocal—for 11 consecutive years, followed by 5 other operators. . The second factor is crew stability. Working together for so long, crewmen learned to work as a team. Third key safety program element is focusing on constant improvement. The belief is that as we approach the year 2000, we must continue to improve our crews' safety performance to protect the customer, and most importantly, our own people.

Productivity, involvement from top management, mutual respect, loyalty, trust, awareness and dependability are words that help to describe a professional worker in today's demanding oil field. Safety leaves a lasting impression and can be one of the best cost-saving actions that any contractor can leave behind at the end of a job.

The description is from "Diamond Offshore Rig 650 celebrates 12 full years without an LTA." DRILLING CONTRACTOR NEWS. September/October 1999.

**4.2.2 Summary on what is good safety culture of rig**

Through analyzing and demonstrating drilling rig accident cases, to build a table to show good elements of rig safety culture.

1	Rig managers' attitude on safety management	Respect the value of all workers, recognizing that fair treatment on every worker is very important for safety. Promoting a healthy lifestyle, non-work related accident should be controlled. Safety management focuses on effective prevention of accidents.
2	On-site workers' attitude on safety management	Most of workers are willing to improving the level of safety and health with rig managers.
3	Drilling worker's behavioral norm	Safety awareness and behavior has become an inherent habit of the majority of workers.
4	Regulations on	Very complete regulations, and has a good changing and

	drilling rig	propagandizing mechanism while external environment or engineering planning changes.
5	Communication in drilling rig	Pay more attention to emotional communication and exchange.
6	Working environment	Humanized and personalized safety working environment, tools and portable devices placed neatly, which can effectively promote working efficiency. Warnings are posted in where is needed, to prevent the potential risks.
7	Principles on treating company internal accident	Identify truly the cause of the accident. The person responsible for the accident should be fairly punished. All employees should learn accident report and get lesson. Develop new measure to prevent similar accidents.

## **Chapter Five: Safety culture model in drilling rig**

Drilling is a high-risk industry, however, problem of safety and health is not isolated problem in drilling rig, and many factors can impact safety and health. For example, high reliable and more humanized can promote workers' safety and health, or adequate investment in safety can make workers to get more safeguards and safe devices. So safety culture covers many aspects of drilling rig and drilling company. On this basis, a more reasonable and realistic definition may be "safety culture is a drilling rig's climate where safety and health concept is really accepted and understood by all employees in a high priority, and necessary resources are provided by company's top managers".

### **5.1 Safety culture influencing factors on drilling rig**

First of all, a good safety culture can be as an example to learn, but it is not possible to completely graft a safety culture from a drilling rig to others, as each organization is unique, and the best safety systems in the world will fail without a supportive culture.

Attitudes, personal education and experience, organizational training, communication mechanism and so on, all of them affect the development of a safety culture in a drilling rig. The environment in which people work and the systems and processes in a drilling rig also impact on safety culture. Therefore, each drilling rig needs to consider all of these aspects in developing and nurturing a safety culture that suits the rig and the individuals within it. In Chapter 4, many accidents and cases indicate that a number of factors are in place in drilling rig that have a good safety culture.

#### **(1) Commitment at all levels**

The drilling rig's manager and top managers of drilling company should take "first of safety and health" as a core value and actively pays attention for the drilling workers and labor. The perspective for the company is that the drilling rig will aim on zero incidents/injuries, and safety and health should be incorporated into all of the work process, rather than only identified high-risk assignment. This attitude of safety management needs to impenetrate the whole company from the CEO to the newest and most inexperienced drilling workers.

#### **(2) Safety and health are seen as an investment, rather than cost**

To provide necessary resources of risk management of safety and health, company has to spend more cost in employee training, safeguard, security defense devices, all of them will increase financial investment. The cost should be seen as investment, and it can deliver better safety performance in drilling rig. Safety financial report should be as a part of the company budget in operation.

### **(3) Safety and health is an process of continuous improvement**

Safety working only has a beginning point, no end. So safety and health is a continuous improvement process. This means that company top managers do not only focus on financial income and strategy development, also spend considerable time and provide necessary resource to enhance safety performance and solve safety issues. Rig managers do not only concern with drilling engineering and equipment maintenance, also focus on risk control, safety management, to optimize safety regulations and to establish humanized on-site management system in drilling rigs.

### **(4) Training and information**

Professional training and information should be provided for everyone who works on drilling rig. Professional training can promote effectively on-site employees' safety skills and safety awareness; reduce risk and accidents which are caused by ignorance. The formal information involved safety and health should provide to on-site employees, it is benefit for learning and carrying out these useful safe and health information in their assignments. And their behaviors can affect other employees. Actually, posters, warning signs and book manuals are not adequate, safety and health information should distribute all working process, and company should establish an access to make employees easily getting information. These requirements of information may involve IT engineering.

### **(5) A good system for risk prevention and control in drilling rig**

Company should build a good management system to prevent and control risk. To better implement risk management, company should have a good survey interactive platform. In the platform, risk managers can research, measure and analyze risk identified, and communicate individual attitudes and perceptions. Risk managers also can easily get video and picture of the current state of the drilling rig, it is benefit for revealing risk and hidden hazard, and they can offer the best solution through analyzing and discussing identified risk and hidden hazard. This action should be conducted at regular intervals in drilling rig or drilling company that strive for building a good safety culture.

A reporting system is necessary, and this system is easy to use, and it is open-ended in whole company. The content filled is not limited in accident occurred, some near misses and identified hazard also can be filled in this report system. These content can be accessed by onshore risk managers and other drilling rigs of this company. If this is the case, other drilling rigs can learn lessons from the reports. These reports also offer mass of evidences to onshore risk managers to improve current risk management policy.

### **(6) The working environment is blame free**

Trust is an important aspect of an excellent safety culture; however, trust often is most difficult barrier in building safety culture. Company should encourage every on-site employee to know that accident and potential risk is worth reporting, and they do not

have humiliating feeling in correcting process, no unfair aftermath can occur on corrected employee. If this is the case, managers can easily know what happen; because of employees can tell them truth, even the truth is not easy to be accepted.

#### **(7) Incentive mechanism**

Incentive is not ignored in building safety culture. Because an excellent safety culture needs every employee to maintain and persist, in this process, company should recognize their contributions, and let employees know that their contributions are worth. A good incentive mechanism is as driven power to strengthen safety culture with a positive effect. Of course, incentive does not only mean bonus, actually, celebration of safety can be diverse ways.

#### **(8) Equipment**

The equipment is a basis for safe production and operations in a drilling rig. High safety and high reliability of the equipment will effectively reduce repair frequency probability of personal injury and economic loss by sudden equipment failures.

#### **(9) Recruitment**

Many drilling companies desire to recruit more employees who have working experience and educational background, but this leads an pressure from more cost invested. Similarly, drilling companies recruit more juniors who do not have drilling working experiences, and train their drilling working skills and safety skills, which make company to assume more risk. Therefore, how to trade off the relationship between cost and risk, this point is human resources to need to consider problems.

#### **(10) Rig managers' attitude on safety management**

Rig managers have interpretative right for regulations, and they have punishment right for violators, so the principle of safety management is an important factor on safety culture. Managing fairness and precise working attitude can impact rig's safety climate.

### **5.2 Drilling rig safety culture model**

Based on the literature review of above chapter, safety culture model and characteristics of the drilling industry, to analyze safety culture influencing factors, and build safety culture model on drilling rig.

Drilling rig safety culture model can divide into five levels; the five levels are as follow:

- Level one: Instinct reaction
- Level two: Passive management
- Level three: Active management
- Level four: Team cooperation and participation
- Level five: Continuous improvement

Each safety culture level has fourteen measured item, each measured items based on drilling rig safety culture level to develop the corresponding description.

<b>Level one: Instinct reaction</b>			
Measured items	1	Company top managers' attitude on safety management	Only cost and economic benefit is important, safety means more cost.
	2	Company's decision on choice of equipment performance and reliability	Price and engineering demand
	3	Human resource's recruitment conditions for new employees	Only considering workforce and personnel quantity demanded.
	4	Safety training from drilling company	No safety training from company
	5	Safety commitment at all levels	No safety commitment
	6	Rig managers' attitude on safety management	Accident is inevitable, in god's hands
	7	On-site workers' attitude on safety management	No safety awareness or low awareness
	8	Drilling worker's behavioral norm	Casual and loose
	9	Regulations on drilling rig	No clear and public regulations, any interpretation of rules based on rig managers' temporary understandings and decisions.
	10	Learning mechanism on	No learning mechanism



		accident report	
	11	Incentive mechanism on safety	No incentive mechanism
	12	Communication in drilling rig	Nobody is informed, no feedback, passively accept working instruction
	13	Working environment	Workplace messy, tools placed at random, nobody concern with workplace environment.
	14	Principles on treating company internal accident	Accident hidden or covered

<b>Level two: Passive management</b>			
<b>Measured items</b>	1	Company top managers' attitude on safety management	Safety problem cannot be regarded as important company risk.
	2	Company's decision on choice of equipment performance and reliability	Begin to consider the reliability of the equipment, but the price and engineering demand remains key factors
	3	Human resource's recruitment conditions for new employees	Only considering workforce and personnel quantity demanded, no training before work, learning while working on rig at same time.
	4	Safety training from drilling company	No systematic training planning, or training motivation comes from superior's requirement or accident, nobody care on the effect of training.
	5	Safety commitment at all levels	No safety commitment or safety commitment only from on-site managers.
	6	Rig managers' attitude on safety management	Accident is inevitable

	7	On-site workers' attitude on safety management	Aim on protecting themselves, passively implement and participate in safety regulations and requirements.
	8	Drilling worker's behavioral norm	Most of workers do not have safety awareness, lack of safety skills.
	9	Regulations on drilling rig	Regulation is not complete or complete but nobody monitors.
	10	Learning mechanism on accident report	Accident report simply learned, but there is no deep discussion and summary.
	11	Incentive mechanism on safety	Incentive mechanism is only used to punish wrongdoers; the type of punishment is determined by the managers, rather than rules.
	12	Communication in drilling rig	Driven power of safety warning is from responsibility of job position ( e.g. toolpusher warns to drilling crew on assigned task or procedure)
	13	Working environment	Cleaning after rig managers required, and nobody to take the initiative to clean workplace. Tools and portable devices are not specialized storing place.
	14	Principles on treating company internal accident	Related manager or leadership is penalized or dismissal, But the effects of the accident is weakened by company internal officers.

<b>Level three: Active management</b>			
<b>Measured items</b>	1	Company top managers' attitude on safety management	Safety included in risk management of company.
	2	Company's decision on choice of equipment performance and reliability	Consider the safety and reliability of the equipment before equipment procurement.

3	Human resource's recruitment conditions for new employees	Preferentially hire employees who have education background and work experience.
4	Safety training from drilling company	Company has systematic training planning, invest on the safety and skill training; employees realize the importance of safety knowledge.
5	Safety commitment at all levels	Recognizing the importance of safety commitment.
6	Rig managers' attitude on safety management	Accident is evitable through management and training, managers realize that most of accidents are caused by unsafe behaviors, use some indicators to monitor safety performance(e.g. TRIR)
7	On-site workers' attitude on safety management	Realize the importance of safety, have the safety awareness of self-protection, initiatively check environment, tools and measures is safe or not before working.
8	Drilling worker's behavioral norm	Be able to consciously obey and implement safety management regulations of drilling platform, shortcuts found in the working process, may ignore safety.
9	Regulations on drilling rig	Promote safety status by improving regulations, procedures and engineering technology, but driven power comes from top.
10	Learning mechanism on accident report	Accident report is widely studied on drilling rig; initiatively develop discussion and summary of accident report.
11	Incentive mechanism on safety	Use the way of reducing accidents and losing manpower hour time to motivate safety performance.
12	Communication in drilling rig	Safety tips interaction between employees in work, workers and managers can take the initiative to deter unsafe phenomenon and behaviors observed.
13	Working environment	Workplace is clean, tools and devices placed neatly, drilling rig has relevant regulations of location management, but it only covers in some places
14	Principles on treating company internal accident	Actively report the accident across company, company employees can know the truth of accident, related manager or leadership is penalized or dismissal

<b>Level four: Team cooperation and participation</b>			
<b>Measured items</b>	1	Company top managers' attitude on safety management	Realize that workers participation is an important aspect to enhance safety level. And drilling company knows that imperfect implementation on relevant policies and rules is a common reason for accidents occurred.
	2	Company's decision on choice of equipment performance and reliability	The safety and reliability of equipment are the most important consideration in equipment acquisition; preferentially select the equipment which is high safety and high reliability.
	3	Human resource's recruitment conditions for new employees	Attaches great importance to the new employee's past work experience, very good and complete assessment mechanism to identify the employee's ability to work, complete and detailed recruitment requirements.
	4	Safety training from drilling company	The workers and managers can easily access safety information they need, attention to occupational diseases, work-related injury insurance and other aspects of knowledge.
	5	Safety commitment at all levels	Complete and systematic commitment at all levels.
	6	Rig managers' attitude on safety management	Respect the value of all workers, recognizing that fair treatment on every worker is very important for safety. Promoting a healthy lifestyle, non-work related accident should be controlled. Safety management focuses on effective prevention of accidents.
	7	On-site workers' attitude on safety management	Most of workers are willing to improving the level of safety and health with rig managers.
	8	Drilling worker's behavioral norm	Most of workers consider that safety and healthy are very important both from a moral or economic point of view, they are willing to assume safety and health responsibility.
	9	Regulations on drilling rig	Very complete regulations.
	10	Learning mechanism on accident report	Rig's workers and managers initiatively organize to learn accident report, and in the platform team and departments to discuss and summarize the cause of the accident, they develop preventive measures, and are able to implement these measures in on-site work.

	11	Incentive mechanism on safety	A complete safety incentive system, workers actively participate in the assessment of the safety performance.
	12	Communication in drilling rig	Safety precautions and risk tips throughout the entire work, regular interval meetings to discuss and summarize the recent safety status and improvement planning.
	13	Working environment	The working environment is clean, tools and portable devices are neatly placed in specialized storing places, and rule of location management covers all working place.
	14	Principles on treating company internal accident	Seriously deal with the personnel responsible for the accident, the more workers get experience and lesson, and the development of relevant preventive measures to prevent recurrence of similar problems.

<b>Level five: Continuous improvement</b>			
<b>Measured items</b>	1	Company top managers' attitude on safety management	Continuous improvement on better risk control theory and methods, a large number of cost is invested on improving safety and health of employees' families, company do not satisfy with results recorded in long-term no accident and no serious near misses. Company also focus on employees' health and family health in no-working time, and provide necessary resources to achieve this concept.
	2	Company's decision on choice of equipment performance and reliability	Depending on using situation, propose reasonable suggestions for improvement, taking into account the humanized design.
	3	Human resource's recruitment conditions for new employees	The employees' abilities and safety skills are as the most important considerations on recruitment. Establishing employees' safety performance files, and in regular interval, rewarding employees who contribute for safety performance.
	4	Safety training from drilling company	The workers and managers can easily access safety information they need, they can get complete and professional occupational diseases, work-related injury insurance training.
	5	Safety commitment at all levels	Complete and systematic commitment at all levels.
	6	Rig managers' attitude on safety	Employees could share safety and health, which is the most important safety management concept.

	management	
7	On-site workers' attitude on safety management	Prevent non-work-related accidental injury is equally important as work-related injury.
8	Drilling worker's behavioral norm	Safety awareness and behavior has become an inherent habit of the majority of workers.
9	Regulations on drilling rig	Very complete regulations, and has a good changing and propagandizing mechanism while external environment or engineering planning changes.
10	Learning mechanism on accident report	Rig's workers and managers initiatively organize to learn accident report, and in the platform team and departments to discuss and summarize the cause of the accident, they develop preventive measures, and are able to implement these measures in on-site work.
11	Incentive mechanism on safety	For confidence in the overall safety management process, company adopts a great variety of indicators to assess safety performance. Set some employee examples who contribute excellent safety performance, use honor and rewarding to infect more employees.
12	Communication in drilling rig	Pay more attention to emotional communication and exchange.
13	Working environment	Humanized and personalized safety working environment, tools and portable devices placed neatly, which can effectively promote working efficiency. Warnings are posted in where is needed, to prevent the potential risks.
14	Principles on treating company internal accident	Identify truly the cause of the accident. The person responsible for the accident should be fairly punished. All employees should learn accident report and get lesson. Develop new measure to prevent similar accidents.

### 5.3 Concluding remark

In the current international context, petroleum and natural gas demand increases year by year, and business of drilling industry is flourishing, so an excellent drilling rig safety culture is particularly important.

Safety culture is not a new question for study or discussion in drilling industry; since the "Deepwater Horizon spill oil" accident shocked the world, the topic of safety culture is active again in drilling industry. In despite of safety and health concept widely accepted, various types of injury accidents and close misses still occur in drilling rigs.

The goal of this thesis is to analyze and discuss the influence factors of safety culture in drilling rig with international working environment, and build drilling rig safety culture model to identify safety culture aspects of drilling rigs. Comparative analysis identifies five levels of safety culture: instinct reaction, passive management, active management, team cooperation and participation, as well continuous improvement.

A successful construction of drilling platform safety culture is to need to overcome many obstacles and difficulties. Strict regulations and safety protective devices can not really achieve inherent safety, these objective policies and devices can not completely replace subjective safety desire. Subjective safety desire from top to down hierarchy, which is a basis of good safety culture existence and development in a drilling company.

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