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Study on pollution management and pollution emergency of offshore oil drilling platform

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STUDY ON POLLUTION MANAGEMENT AND POLLUTION EMERGENCY OF OFFSHORE OIL DRILLING PLATFORM

By

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation: **Study on Pollution Management and Pollution Emergency of Offshore Oil Drilling Platform**

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Offshore has become an important area of development for the oilfield industry. As a high-risk site for safety and environmental protection in oilfield operations, the implementation of safety management is essential to maintain the smooth running of offshore oilfield operations.

Based on the analysis of accidents of offshore drilling platforms in recent years, this paper expounds the importance of pollution management and emergency measures for offshore oil drilling platforms, and analyze the types and causes of current platform pollution, including merchant ship collision, extreme weather, improper human operation, etc., then clarify the existing management measures and early warning mechanisms.

In combination with the special emergency plan and the relevant documents of the Shipboard Oil Pollution Emergency Plan and with reference to the relevant requirements for pollution management of offshore oil drilling platforms in China and relevant foreign management regulations, the problems that still need to be solved to deal with platform pollution are compared and analyzed.

By putting forward relevant pollution management and emergency measures, the quality of pollution management and emergency plan can be improved to meet the current needs of offshore oil pollution prevention and control.

KEY WORDS: Pollution Management, Pollution Emergency, Offshore Oil Drilling Platform, Environmental Protection

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LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
API	American Petroleum Institute
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BOP	Blowout Preventer
BP	British Petroleum
CNOOC	China National Offshore Oil Corporation
COGOA	Canadian Arctic is the Canadian Oil and Gas Operations Act
COSL	China Oilfield Services Limited
DECC	Department of Energy and Climate Change
DOI	Department of the Interior
EPA	Environmental Protection Agency
FMEA	Failure Mode and Effect Analysis
FRR	Facility Risk Review
HAZOP	Hazard and Operability
HSE	Health and Safety Authority
INAC	Indian and Northern Affairs
MOU	Memorandum of Understanding
MSS	Mineral Management Service
NEB	National Energy Board
NOAA	National Oceanic and Atmospheric Administration

OCSLA	Outer Continental Shelf Lands Act
OIM	Offshore Installation Manager
PRA	Probabilistic Risk Assessment
PSA	Petroleum Safety Authority
SEMS	Safety and Environmental Management System

CHAPTER 1

Introduction

1.1 Research background

With the rapid development of society, people's demand for oil is increasing year by year. Nowadays, oil exploration and development technology has been fully developed, but the exploration and development of offshore oil is still in a rapid development stage. Because the oil resources is depleting on land, countries have begun to explore offshore oil. Offshore rigs are mobile drilling units located offshore to efficiently exploit oil resources at a distance from land. In 2019, there were 26120 drilling platforms in the world. Such a large number of drilling platforms not only brought us oil and gas resources, but also brought huge risks, such as pipeline rupture, well blowout, bad weather or collision with ships, which will lead to oil spill pollution accidents. This may cause serious ecological problems, pollute the marine environment, disrupt the balance of the ecological chain and have a huge impact on the economy, as well as bringing harm to people's health and safety. In the face of the huge risks posed by oil platforms, effective oil platform pollution management systems and pollution contingency plans play a vital role in preventing and dealing with offshore oil spills. Therefore, aiming at this hot issue of concern, this study will explore the necessity of establishing safety management and emergency mechanism; find the problems still existing in pollution prevention, treatment and emergency response after sorting out the existing domestic and foreign relevant oil platform pollution management policies and emergency plans. It also summarizes the causes and types of pollution caused by offshore oil drilling platforms, and puts forward corresponding measures and suggestions to deal with the pollution of offshore oil drilling platforms.

According to the statistics of NOAA in the United States, among the major oil spills near the waters of the United States since 1969, the oil spills of the Deepwater Horizon drilling platform in 2010 and Ixtoc No. 1 oil well in 1979 still rank first in all types of oil spill disasters (NOAA, 2022) (as shown in Figure 1.1).

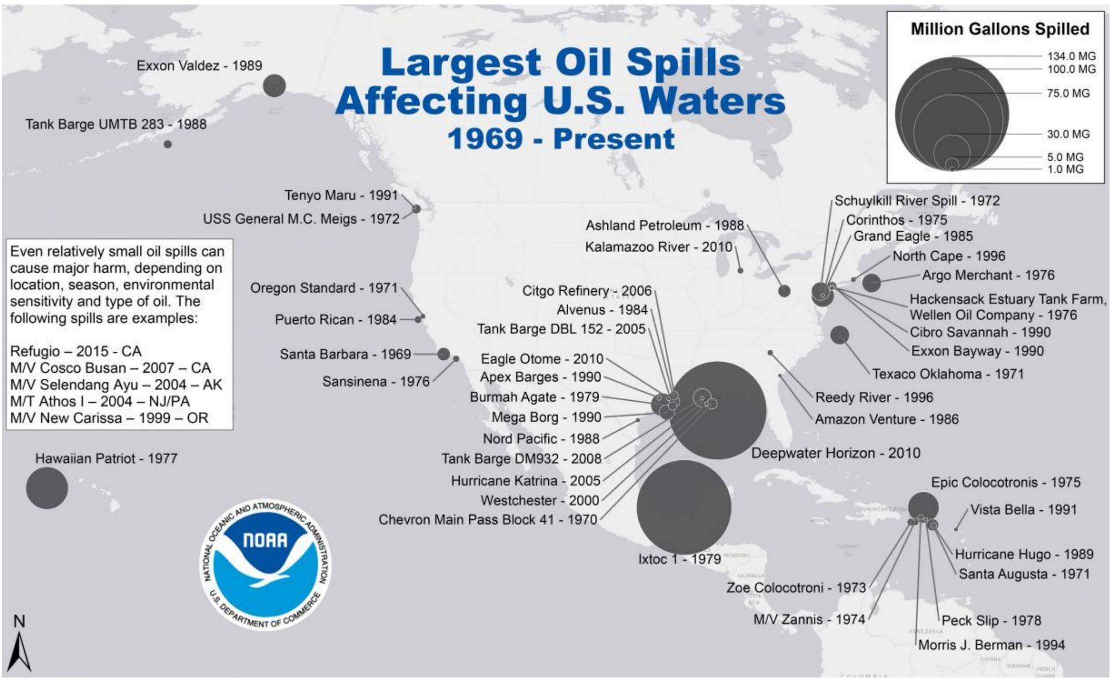

Figure 1.1 Largest oil spills affecting U.S. waters 1969-present

Source: NOAA (2022)

1.2 Current status

With the continuous development of offshore drilling platform technology, more and more problems have to be solved. Due to the great harmfulness of offshore drilling platform accidents, relevant preventive measures, emergency measures and solutions should be constantly updated and improved. In order to effectively reduce the pollution risk of offshore drilling platforms, it is necessary to formulate higher standards and enact stricter management measures, and further put the awareness of crisis prevention first by putting forward more appropriate plans in laws and regulations. These are the key issues that offshore drilling platforms need to pay attention to all the time.

1.2.1 Study on accidents of offshore drilling platform

Duan Mingxing and others analyzed the accident data of offshore oil development in the UK and the United States, and concluded that the accident risk of drilling platform is high, and preventive measures must be strengthened (Duan et al, 2021). On April 20, 2010, the Deepwater Horizon drilling platform rented by BP in the Gulf of Mexico exploded, causing a large number of oil spills and an economic and environmental tragedy. The US government confirmed that this event became the "most serious" oil spill in US history, which exceeded the 1989 Exxon Valdez oil tanker spill in Alaska. In 2010, Chen Jiding and others reflected on the oil spill in the Gulf of Mexico and suggested that preventive measures such as strengthening emergency action, clarifying emergency responsibilities and improving the attention of local governments should be taken to strengthen the prevention of oil spill on drilling platforms (Chen et al, 2010). The oil spill that occurred in June 2011 at the Penglai 19-3 oil field developed by ConocoPhillips and CNOOC caused great pollution to the water quality of the surrounding waters, and the water quality of the serious waters was reduced from Class 1 to inferior Class 4. After the accident, oil eliminators were used to clean up the oil pollution. The harmful substances produced in the process of oil decomposition will be absorbed and accumulated by marine organisms first, which will finally threaten people's health as they are transmitted along the food chain. ConocoPhillips was accused of inadequate handling of the Bohai Sea oil spill and in April 2012, ConocoPhillips and CNOOC paid a total of RMB 1.683 billion to compensate for damage to marine ecology and farmers caused by the oil spill. In response to this serious accident, in "Reflections and suggestions on the oil spill in the Gulf of Mexico", Chen Jiding, Geng Hong and Chen Xuan believed that the Bohai No. 2 shipwreck had dealt a heavy blow to the development of China's petroleum industry at that time. In 2011, Wang Canfa and Huang Jing proposed to improve the legal mechanism of marine environmental protection in response to the oil spill accident of ConocoPhillips, cooperate with different law enforcement departments to affect the law enforcement, pay attention to civil prevention of marine environmental damage, strengthen the disclosure of marine environmental pollution information, and strengthen public supervision over violators (Wang Canfa et al, 2011). An oil spill accident on an offshore drilling platform will have a great economic impact. Zhang Yijing analyzed the oil spill accident in the Gulf of Mexico in 2010 and the oil spill pollution accident in Peng lai 19-3 oilfield in China in 2011. The establishment of a compulsory liability insurance system for oil pollution from offshore rigs was proposed due to the fact that oil spills not only cause great damage to the marine environment and coastal industries, but also result in hundreds of millions of dollars in compensation to oil companies (Zhang Yijing, 2016). The fire in Baghjam oil well in India in 2020 continued to burn for 172 days. Dong shows that the Indian side's backward treatment of the burning of the oil well has brought extremely serious damage to the ecological environment (Dong Xiaobai, 2021).

Therefore, it is urgent to strengthen the treatment and prevention of oil leakage and spillage on the drilling platform.

1.2.2 Offshore drilling platform management policy

Xie Xiyong and Zhang Ningning summarized the problems and causes of emergency management of offshore oil platforms through practical investigation, which are mainly reflected in the limited resources of emergency management, the bottleneck of emergency drill effect and the special operating environment of offshore oil platforms (Xie Xiyong et al., 2019; Zhang Ningning, 2021). In view of the problems existing in offshore oil exploitation, the author solve the problems one by one from the aspects of resources, drilling, environment and so on; And do a good job in the supply of emergency equipment and emergency resources for offshore oil platforms, and comprehensively improve the emergency rescue work; exercise activities shall be carried out regularly in strict accordance with the requirements of the emergency rescue exercise, so that the emergency rescue work can be carried out smoothly. Environmental, Health, and Safety Guidelines for Offshore Oil and Gas Development proposes to formulate emission guidelines, environmental monitoring and use performance indicators to monitor potential health and safety problems of businesses and monitor performance indicators in combination with the requirements for assessing environmental problems of offshore drilling platforms. In 2017, Pan Qimade some suggestions on the oil spill from an offshore oil platform in the United States, and also suggested improving China's contingency planning for offshore emergency response, so as to improve China's emergency response capability in offshore oil spill incidents and to more strongly safeguard offshore operations and transportation safety (Pan Qi, 2017). There are many high-risk factors on offshore oil rigs, and in 2018, Chen Jiao theoretically enhanced the life and property safety of offshore oil rig operators by proposing risk maintenance principles, and risk maintenance strategies for offshore oil rigs(Chen Jiao, 2018). Li Qinglin analyzed the main types and causes of safety accidents on drilling rigs, summarized the causal factors of offshore oil drilling risks and put forward a series of recommendations for safe production in oil extraction (Li Qinglin, 2019). In 2020, Zhang Yu proposed a model for the minimum safe distance between a drilling rig and different ship captains built by combining the influence of the ship's domain and wind and flow, and proposed a solution for the risk of interaction between the rig and the surrounding traffic flow (Zhang, 2020). In 2021, Ma Huifang achieved the goal of speeding up the response to emergencies by establishing a tight early warning system, setting up a special platform team, improving the emergency awareness of enterprises and employees, and clarifying responsibilities (Ma Huifang, 2012). In 2021, Wang Qiang et al. used FDS software to establish a numerical model to determine the diffusion of smoke and temperature over time after a fire incident on an offshore platform, taking into account the actual working conditions of the platform (Wang Qiang et al., 2021). A mathematical model of personnel evacuation was established to obtain the approximate path of personnel evacuation, calculate the time required for evacuation and give the best evacuation path.

1.2.3 National laws and regulations

As oil spills will cause serious pollution, in 2014, the State Oceanic Administration formulated the Emergency Plan for Oil Spills in offshore oil exploration and development of the State Oceanic Administration, which further improved China's emergency response procedures for oil spills on offshore oil drilling platforms from three aspects: offshore oil spill detection, pollution source control of oil spills on offshore oil drilling platforms, recovery of oil spills on the sea surface and offshore oil pollution cleaning (Hossain et al, 2010). In 2011, when comparing Canada, the Arctic, the United States, the United Kingdom, Greenland and Norway, Jennifer Dagg and others compared the laws and regulations of different regimes on drilling platforms, and studied the different management requirements of drilling platforms in different regions. In 2013，Lee cordner proposed the regional safety and security challenges in the Asia Pacific region and provided policies to address the security challenges (Dejan et al, 2021). The regulations add additional requirements for petroleum gas production and storage devices, as well as requirements for aversion detection of drilling inlet (only for accommodation area) (DNVGL, 2017). In 2018, Wang Dongshi introduced the regulatory framework of petroleum activities in the Norwegian continental shelf, summarized the Norwegian laws and regulations on drilling platforms, and proposed that the requirements of PSA on the working environment of offshore oil facilities should be fully considered in the selection and design stage of Norwegian drilling platforms (Wang Dongshi, 2018). In April 2020, API updated the safety standard for offshore drilling platforms in the Improvements to Offshore Safety Report (API, 2020). In march2021, the US Government Accountability Office requested the Congress to report that pipeline supervision needs to update the regulations on offshore oil and gas (Nazarudin et al, 2014). In April 2021, Tang et al. published offshore oil and gas safety review in the policy framework to update a series of laws and regulations related to offshore oil and gas safety review in Australia (Tang et al, 2018).

1.2.4 Development of pollution prevention technology for offshore drilling platforms

The semi-submersible offshore drilling platform was further developed by R. Sharma et al. in 2010 (R. Sharma et al, 2010).In 2010, Liang Haiming adopted slim hole drilling technology and concluded that the smaller the borehole size, the smaller the amount of waste drilling fluid and drilling cuttings, and the less pollutants(Liang Haiming, 2010). In 2014, OTS copied the platform equipment and system, proposed a high-precision simulation of offshore oil platform operation, planned the process model of the drilling platform in stages, and improved the safety and efficiency of the drilling platform (Ilya et al, 2014). There are many high-risk factors for offshore oil drilling platforms. In 2018, Chen Jiao (Chen Jiao, 2018) proposed risk maintenance principles and risk maintenance strategies for offshore oil drilling, theoretically improving the life and property safety of offshore oil drilling platform operators. In 2019, Chen Hongjian analyzed the example of overload failure of the ship's streamer during deep-water anchor dropping operation of the drilling platform, and proposed to reduce the external load, improve the bearing capacity of the equipment and the hydraulic motor, and ensure the overload protection function of the equipment. He also put forward some precautions for the use and management of the streamer (Chen Hongjian, 2019). Chen Shenggen believes that explosion-proof electrical equipment is important equipment in offshore oil drilling (Chen Shenggen, 2021b). All equipment should be regularly inspected to effectively avoid safety accidents caused by equipment failures, reduce the accident rate and ensure the safe and smooth completion of oil exploration and development. Zhong Ying suggests that it is necessary to regularly check who is being inspected at shift change to ensure that all equipment is functioning properly and to build a professional construction machinery management and maintenance team (Zhong Ying, 2020). In 2019, Chen Hao and Xie Chengchao proposed to use UAVs to conduct real-time monitoring of offshore platforms in their research on the application of UAVs in patrol inspection and emergency rescue of offshore oil platforms, providing an advanced technical means for emergency rescue at the scene of oil spill accidents, complementing satellite remote sensing, man-machine monitoring, ship patrol inspection and other means, improving drilling platform management and accelerating emergency response (Chen Hao et al, 2019). In 2020, Zhang Dayong and others simulated the maximum stresses of structures such as columns, cables and bulkheads by ANSYS, giving the failure modes and evaluation methods of semi-submersible platform structures and accessories under the action of sea ice, and achieved great results in the anti-ice performance of semi-submersible marine platforms(Zhang Dayong et al., 2020).In 2021, Yue Ming and others established criteria for the design of wastewater collection compartments for drilling platforms based on the characteristics of the medium platform process and bin capacity (Yue Ming et al, 2021). They transformed Bohai No. 5 drilling platform and successfully realized the technical requirements of "zero discharge" of domestic sewage. Good technology also requires good implementation. In 2021, Cheng Haodong, in conjunction with his participation in ship supervision inspections, verified the domestic sewage treatment systems of 30 ships and found that there were currently significant divergences in the retrofitting paths of domestic sewage treatment systems, resulting in domestic sewage not being treated in accordance with regulations (Cheng Haodong, 2021). Pi Xinyan introduces the definition of ship domestic sewage, discharge standards and the characteristics of several major technologies (Pi, 2019). A comparative analysis of several major technologies is presented based on the development of domestic sewage treatment technologies for offshore oil and gas platforms/vessels in the last decade or so. The situation of the singularity of treating domestic sewage at sea is enriched. In the Scotian project, the "j", "u" and "v" shapes used by ships to recover spilled oil in the event of an offshore oil spill are described (BP, 2015).

In conclusion, with the increasing number and advancement of offshore drilling platforms, scholars at home and abroad pay more and more attention to the research of drilling platforms. The operation specifications, oil leakage treatment and safety management of platforms are all hot issues. However, these studies mostly focus on theoretical methods and macro research. In practical work, the operation of offshore drilling platform is extremely inconvenient because it is far from land. The safety of drilling platform is affected by many factors, including the prediction of extreme weather and how to deal with it, but it is not easy to make field test for severe hydro-meteorological conditions. Therefore, it is still necessary to improve the offshore drilling platform through constantly updated national laws and regulations and the existing policies of offshore drilling companies.

1.3 Research content

Combined with safety management theory, accident theory, pollution theory and emergency theory, this paper discusses the necessity of establishing safety management and emergency mechanism. Analyze the types and causes of pollution on the platform, and improve the corresponding management measures. Referring to the accidents of offshore oil drilling platform in recent years, this paper analyzes the causes of platform pollution emergency, and puts forward the preventive measures and the improvement of relevant early warning schemes. According to the comparison of pollution management and emergency measures at home and abroad, this paper discusses how to connect the relevant government bills and the measures of oil platform enterprises. According to the actual situation of all aspects, it provides relatively perfect pollution management and pollution emergency measures and suggestions.

CHAPTER 2

Theoretical Basis

2.1 Safety management theory

In the process of offshore drilling platform management, safety management is the focus of enterprises, and there are many studies on employee safety behavior management. Safety management is mainly divided into accident prevention and accident control. Safety theory states that there is no absolute safety for all employee behavior, only relative safety Enterprise managers should analyze the risks existing in the operation and reduce the possible safety risks to an acceptable level, and they will recognize the safety of the operation. The purpose of safety management is to reduce the probability of safety accidents, including technical means and management skills (Zhou Saijie, 2020).

2.2 Pollution theory

Pollutants refer to substances that change the normal composition of the environment after entering the environment and are directly or indirectly harmful to biological growth, development and reproduction. The pollution produced by offshore oil drilling platforms is mainly water pollution and air pollution.

One is water pollution, which is divided into oily sewage, domestic sewage and rubbish according to the Ship Water Pollution Discharge Control Standard. Oily sewage is the sewage containing residues of other oil machines such as fuel oil and lubricating oil produced in the operation of the platform (Bi, 2020). Domestic sewage mainly refers to the domestic sewage produced by workers on the platform, including the discharge from the large and small urinals of the ship's toilets and other wastes, the discharge from premises containing movable objects, etc., but excluding grey water produced by daily life washing, such as bathing and washing vegetables. Domestic Rubbish includes mainly various kinds of plastic waste, food waste and household waste generated by the daily life of people on the platform. Secondly, air pollutants mainly refer to Sulphur oxides, nitrogen oxides and particulate matter contained in the exhaust gas produced by ships after using fuel oil. Pollution is affected by human factors and objective factors. Human factors include oil spills caused by improper work of workers, etc.; objective factors include atmospheric pollution caused by Sulphur and nitrogen gases produced by drilling rigs during the production process, etc.

2.3 Offshore drilling operation and risk identification method

2.3.1 Risk factor

Risk early warning is to establish a risk prediction system based on the safety information, risk identification and risk assessment results collected in the early stage during the drilling operation to predict the possible accidents, scale, impact scope and consequence severity during the drilling operation. At the same time, the risk prediction results are updated in time at different operation stages and at different times according to the risk monitoring results and appropriate measures can be taken to issue risk alerts or warnings in advance, remind and notify relevant departments and personnel, so as to take timely and effective measures to prevent the occurrence and development of accidents to the greatest extent and reduce the consequences of accidents (Deng Haifa, 2012). The risk factors of offshore drilling operations include environmental factors, geological factors, technical factors, equipment factors and management factors (Lu Hongfei, 2018).

2.3.2 Risk assessment method

As a technical means, risk assessment can reveal the mechanism of accidents and the role of various protective measures in the process of accidents. The assessment includes risk identification, failure frequency assessment, failure consequence assessment and risk assessment. At present, with the rapid development of modern mathematics and computer technology, qualitative and quantitative methods are mainly formed. These methods have been widely used in nuclear industry, petrochemical industry, coal and other fields. The operation process of qualitative evaluation is the most convenient. This method requires the least amount of data, and relatively few skills are used in the evaluation process. It only needs to analyze the evaluation object to a minimum. Quantitative evaluation requires a comprehensive analysis based on a large amount of data. Semi quantitative assessment is between qualitative and quantitative assessment. Different methods have different application conditions and scope of application, which need to be selected after comprehensive consideration according to the characteristics of the evaluation object.

- Qualitative assessment, i.e. methods for analyzing and judging the safety situation of a system with the help of expert knowledge and experience, e.g. safety checklist, pre-hazard analysis, HAZOP (Interoperability) analysis, FMEA (Failure & Disinfectants) analysis, Bow-Tie analysis, etc..
- Quantitative assessment, i.e. methods for determining the probability of occurrence and consequences of hazardous events by building mathematical models based on statistical data, standard information, etc., such as fault tree analysis, event tree analysis, Bayesian network method, Probabilistic Risk Assessment (PRA), etc.
- Semi quantitative evaluation is a method between two evaluation methods, that is, the method of quantitative risk evaluation is adopted, but it does not produce the results of quantitative analysis, such as fault tree and event tree analysis, FRR (facility risk review), analytic hierarchy process (AHP), fuzzy comprehensive evaluation method, etc.

Because offshore drilling engineering is an extremely complex system engineering, there are many risks, and there are many alternative risk assessment methods.

2.3.3 Risk identification in drilling operations

In the risk analysis of drilling operations, the identification of the main risk factors is an important part of risk management. Risk factors affecting the safety of deep-water drilling operations include physical hazards and the risks encountered during the process. In this paper, based on extensive research of domestic and international research materials, the main risk factors affecting the safety of drilling operations are analyzed to better reflect the degree of safety of drilling operations. There are many risk factors in the drilling process, including not only the unsafe behavior of personnel, the unsafe condition of drilling equipment and other objects, and the harsh marine environmental conditions, but also the safety management issues of the company, and the geological conditions risk factors. The interaction of these factors can lead to serious accidents during drilling operations (He Sha et al, 2012).

2.4 Necessity of establishing safety management and emergency mechanism

2.4.1 Establishment of safety management mechanism

As a high-risk industry, offshore oil faces many safety factors. Therefore, it is particularly important to improve the safety management level in the process of oil drilling operation. Improving the emergency management level is not only a remedy for the lack of safety management measures, but also a key first-aid measure to ensure the safety of employees. In the management process of petrochemical enterprises, safety management is the most important; and safety management is divided into accident prevention and control. For the managers of the enterprises, they have to reduce the risk factor of the whole production process to an acceptable level in order to avoid the occurrence of accidents.

The basic requirement of safety management is to regulate the safety behavior of employees and maintain the correct operation of the production process to protect the lives of employees to the greatest extent possible. However, in this process, the failure of managers to provide relevant training and immediate supervision and monitoring of employees in safety production is also an act of irresponsibility and failure to fulfill the relevant obligations of safety management, which may even produce greater safety hazards. Therefore, managers play a more important role than that of the employees. In the daily safety management of enterprises, managers should follow three basic principles: strengthening education-he principle of prevention beforehand; safety supervision- the principle of timely remediation; emergency rescue-the principle of correct response. The ultimate goal of safety management is to eliminate dangerous behavior until the probability of employee casualties is close to zero. Safety management is divided into four main parts: daily management, information monitoring, system analysis, education, and guidance (Zhou Yi, 2021).

The special nature of the environment is that the drilling platform is far away from land. In order to protect the lives of the workers on the drilling platform, the enterprise managers must establish a perfect emergency management mechanism. In the event of any accident, they can take timely action in accordance with the contingency deployment strategy, activate the corresponding emergency management measures, and ensure timely liaison and report to all departments so that rescue work can be carried out in the shortest possible time, which can reduce the casualty rate of personnel in the accident. Therefore, the three aspects of the accident, namely the casualty rate, damage to rig equipment and property loss, and the level of marine pollution, can be minimized. This minimizes the negative impact on the rig and the company (Lu Hongfei, 2018).

2.4.2 Safety barrier technology for major accidents in drilling operation

Safety barrier refers to the physical or non-physical methods designed to avoid, prevent, control, or reduce the occurrence of unexpected events or accidents. It can be seen that the safety barrier should have four functions: avoidance, prevention, control and reduction. Avoidance means suppressing the essential conditions that cause an event by changing the design of the equipment or the type of materials used (e.g. using non-combustible materials to avoid generating fire) and creating a corresponding system of active, permanent, physical safety barriers so that hazardous events cannot occur. Prevention refers to the establishment of obstacles in the process of accident occurrence to suppress some factors causing the accident or reduce the severity of the accident, to prevent and suppress the possibility of accident occurrence. This function can only reduce the probability of accident occurrence, but cannot absolutely avoid the accident. The control function is to make the system return to the "safe" state after deviation and error, or make the accident under control by taking corresponding safety barriers. Reduction is to limit the time, space of the event, reduce the size of the event or the harm of the dangerous phenomenon to the surrounding equipment, personnel or environment by taking corresponding safety barriers (Deng Haifa, 2012).

2.4.3 Necessity of establishing early warning system

- Determination of alarm indicators

The alarm situation for offshore oilrig safety is an objective description of the safety status of the platform and is a basic indicator of platform safety. To determine the alarm situation, it must be described with the help of a number of indicators. Alert indicators are indicators of the safety or otherwise of a drilling rig.

- Determination of warning indicators

For rig safety, warning indicators are precursor indicators related to oilrig safety, which foretell the development status and future trend of offshore rig safety warning indicators. It is a more sensitive indicator that can predict the trend of offshore rig safety and leads to significant changes in the safety status of the rig.

CHAPTER 3

Types of platform pollution and corresponding management measures

The waste oil generated on the platform is roughly divided into 8 categories: domestic sewage, all sewage from the machinery department, rainwater collected on the deck, production sewage from the drilling area, waste oil generated by machinery and equipment, food waste, fuel pollution and metal waste.

3.1 Domestic sewage and management measures

The domestic sewage comes from the living area and is divided into black water (from toilets, wards and downpipes) and grey water (from baths, kitchens, washbasins, etc.), which, according to the current convention, has to be treated in accordance with the convention before it can be discharged into the sea. Grey water, which is not compulsory, but which also contains high levels of toxic substances and toxic micro-organisms, as well as a high COD and BOD content, is now proposed for compulsory treatment as black water, and these lines are now laid out so that they can go together into the biological effluent storage tank (COSL, 2021a). Domestic sewage treatment units and oil-water separation units on drilling platforms should be used to treat domestic sewage to meet the requirements of international conventions and the laws and regulations of coastal countries before it is discharged into the sea.

3.2 Oil-polluted water

Oily effluent generally includes effluent containing crude oil, fuel oil, lubricating oil and various other petroleum products and their residues generated at the engine room, deck and drilling platform. Oily effluent from machinery premises is collected in a unified manner in a sewage settling cabinet and separated by a 15-ppm oil-water separator before being discharged into the sea. For example, a drilling platform is equipped with five water tanks called open drain, which are respectively from the deck rainwater. The cabin has two chambers connected at the lower part. The sewage flowing through the first chamber is naturally separated by sedimentation, and the oil is accumulated and floating on the surface. The purified water flows into the second chamber through the lower connection. A 15-ppm oil detector is installed on the sea-going pipeline. Once the sewage of the outlet pipeline is detected, the sea-going valve will automatically close with an alarm. At this time, the operator shall manually transport the sewage to the sewage collection tank through the sewage pump. After treatment by the oil-water separator, the separated waste oil will automatically enter the waste oil tank and be sent to the shore for treatment after a certain amount is collected (COSL, 2021c).

The waste oil and sewage from machine production, including those separated from oil and water, are collected into a collection tank called waste oil tank and sent to a qualified third party for treatment. Oily sewage discharge shall meet the following requirements：

- The oily water in the engine room and deck of the platform shall not be discharged except in designated areas, and the discharge concentration in other areas shall be less than 15mg/l.
- Oily sewage from self-propelled platforms (except bilge oil sewage from cargo oil pumps of non-oil carriers and oil sewage mixed with cargo oil residues) can be discharged during navigation after being treated by oil-water separator in general areas, with an oil content of no more than 15ppm. Special areas shall comply with the requirements of special areas.

3.3 Drill floor sewage

A large amount of sewage is generated in the drill floor area. The drilling fluid is divided into water-based drilling fluid and non-aqueous drilling fluid, of which non-aqueous drilling fluid is divided into oil-based drilling fluid and synthetic based drilling fluid; According to the type of drilling fluid used in drilling, drilling cuttings can be divided into water-based and non-water-based drilling fluid drilling cuttings. The platform will dispose waste drilling fluid and rock cuttings in accordance with international conventions and laws and regulations of coastal countries; since oil-based mud is sometimes used and contains certain chemicals, the mud leakage will also bring pollution to the environment. Therefore, the so-called hazardous water system is specially arranged on the platform, the equipment of the hazardous water separation device be divided into two parts. The first stage is solid-liquid separation, which separates the solid substances in the liquid and transports them to the collection device for shore treatment. The remaining oil-water mixture is sent to the next stage for treatment, i.e. centrifuge, which is used to separate the waste oil components in the water. The principle is the same as that of the oil-water separator. All sewage and mud flowing from the area related to the drill floor shall be collected into the hazardous water collection tank and then wait for treatment by the treatment device. All discharged drilling fluid and drilling cuttings shall comply with the standards of coastal countries.

Table 3.1 discharge standard of drilling fluid and drilling cuttings

Types of pollutants discharged	Pollution parameters	Sea level	Emission requirements / limits
Water based drilling fluid and water-based drilling fluid cuttings	oil content	First Level	Except that drilling cuttings and drilling fluid of drilling oil layer shall not be discharged in Bohai Sea, oil content of other first-class sea areas shall be ≤ 1%
		Second Level	≤3%
		Third Level	≤8%
	Hg（Max）	First Second Third Level	≤1mg/kg
	Cd（Max）	First Second Third Level	≤3mg/kg
Non aqueous drilling fluid cuttings	oil content	First Level	Except that the discharge of non-aqueous drilling fluid cuttings is prohibited in the Bohai Sea, the oil content in other class I sea areas is required to be ≤ 1%
		Second Level	≤3%
		Third Level	≤8%
	Hg（Max）	First Second Third Level	≤1mg/kg
	Cd（Max）	First Second Third Level	≤3mg/kg

Source: COSL(2021)

If the requirements of operators for drilling fluid and drilling cuttings are higher than the requirements of international conventions and laws and regulations of coastal countries, the drilling fluid and drilling cuttings shall be treated according to the requirements of operators. During operation in the sea area of China, the non-aqueous drilling fluid (oil-based drilling fluid and synthetic based drilling fluid) shall not be discharged into the sea from the drilling fluid and drilling cuttings generated by platform operation. The drilling cuttings of non-aqueous drilling fluid, water-based drilling fluid of drilling oil layer and water-based drilling fluid of drilling oil layer shall not be discharged in the Bohai Sea area. In other sea areas, when it is really difficult to recover water-based drilling fluid, water-based drilling fluid cuttings and non-water-based drilling fluid cuttings, they can be discharged into the sea after being approved by the competent department of the sea area where they are located. The discharged water-based drilling fluid, drilling cuttings of water-based drilling fluid and drilling cuttings of non-aqueous drilling fluid shall meet the relevant requirements of the Table 3.1 drilling fluid and drilling cuttings discharge standards (COSL, 2021b).

3.4 Other production sewage

Food waste from the kitchen is treated in accordance with the convention. Pollution from fuel refills is dealt with in accordance with emergency oil spill procedures; metal and toxic wastes, as well as hazardous chemical wastes are covered by the waste management plan.

3.5 Oil leakage

Crude oil and its refined products are complex chemical mixtures with high fire and explosion risk index. At the same time, they are also very harmful to human body. When flowing to the sea or river, they will damage all kinds of marine organisms and water quality itself. The treatment of oil spill sewage after oil spill accident on offshore oil drilling platform consists of three parts: pollution source control of oil spill on offshore oil drilling platform, oil spill recovery on the sea surface and coastal oil pollution cleaning. As a part of offshore oil spill emergency treatment, oil drilling platforms and ships' oil spill emergency treatment are basically the same in terms of offshore oil spill recovery and coastal clean-up, regardless of the type and use of equipment, or the method of emergency treatment. The only difference is that it is more difficult to control the pollution source of oil spill from offshore oil drilling platforms than that from ships. As the crude oil is gushing from the seafloor several hundred meters below the surface and spreading by transport in between (as shown in Figure 3.1), it is harder to find the leak point than a ship's oil spill. Secondly, seabed construction is very difficult. If the pollution source cannot be effectively controlled, crude oil is continuously ejected from the seabed, and the consequences are more serious than ship oil spills, such as the Deepwater Horizon oil spill in the Gulf of Mexico. The following is a comparison of the emergency response between the ConocoPhillips oil spill and the Gulf of Mexico oil spill (Wang Canfa et al, 2011).

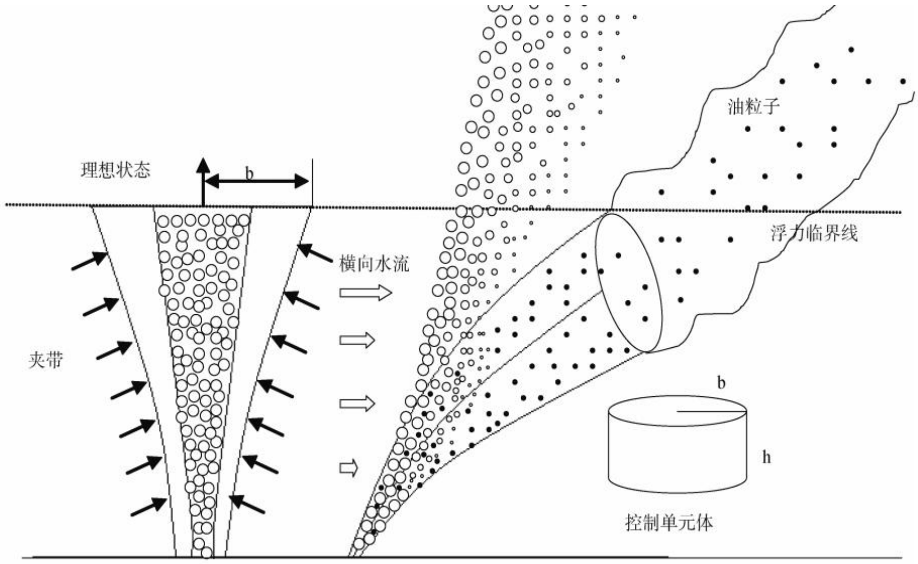

Figure 3.1 Oil spill diffusion

Source: Wang Canfa et al, 2011

CHAPTER 4

Causes of platform pollution emergency

With the increasing exploration and development of offshore oil, the proportion of offshore oil and gas production has gradually increased, and China's offshore has formed a production capacity of more than 5000×104t of oil, with more than 400 fixed platforms built and more than 5000km of submarine pipelines, forming an intertwined submarine oil and gas transmission network between platforms and platforms and land (Wei Xue Cheng, 2019). With the continuous development of offshore oil and gas resources, the scale of the submarine pipeline network will increase and the impact on the marine ecological environment will become increasingly serious. In the event of crude oil leakage caused by pipeline perforation, accidents or human damage, it will not only cause huge economic losses, but also lead to international disputes. More seriously, leaked crude oil floating in the ocean or other waters will seriously damage the marine, coastal and other water environment, causing irreparable ecological damage. This section focuses on the analysis of fire, explosion, platform collision and extreme weather, combined with the requirements of the relevant system of China Oilfield Services Company Limited to prevent relevant things from happening.

4.1 Fire explosion

4.1.1 Fire and explosion accidents of drilling platform

On 27 July 2005, the Indian Oil and Gas Corporation's Mumbai Field No. 1 rig collided with a supply vessel due to violent storms, and the fuel on the supply vessel caught fire and quickly spread to the rig, where the fire quickly engulfed the rig with wind and eventually led to its collapse. The accident resulted in five people dead, 44 missing and direct economic damage of US$2.3 billion (Xuefei Song, 2011).

On 20 April 2010, the Deepwater Horizon drilling rig, chartered by BP, exploded and burst into flames in the northern Gulf of Mexico. The accident caused the loss of control of the underwater wellhead. Since April 24, a large number of oil leaks have started, with a rate of about 5000 barrels per day. The accident caused about 4.4 million barrels of crude oil to flow into the Gulf of Mexico, forming a pollution area of 9971km2, which had a serious impact on the ecosystem, fishery and tourism of the Gulf of Mexico and its coastal areas, and became the most serious oil pollution disaster in the history of the United States.

Figure 4.1 Deepwater Horizon drilling platform explosion accident

4.1.2 Fire and explosion analysis

Offshore rig fires and explosions differ from those on land in that the crude oil is highly mobile and the fire spreads more quickly. The distance from the coastline makes rescue difficult, and the limited escape areas can easily result in mass casualties. In addition, there is a large amount of equipment on the platform, which is expensive and can cause large economic losses (Lei Xiaofan 2010). The main forms of fires and explosions on platforms are jet fires, flash fires, oil pool fires and ball fires, which are the main forms of concentration. The main types and characteristics of fires are shown in Table 4.1.The particularity of offshore drilling platform operation determines its characteristics of fire and explosion, and puts forward higher requirements for offshore platform safety. During the design and production of the platform, measures that are more rigorous are proposed to deal with the potential hazards in different areas. In the process of oil and gas exploration and development, regular grid safety inspection and risk assessment are necessary. Only in this way can the platform accident be minimized and the safety of personnel, property and environment can be guaranteed to the greatest extent.The dangerous areas of fire and explosion are divided into three categories, namely, category 0, category 1 and category 2. Class 0 hazardous areas are area where fire and explosion hazards are often generated or hazardous substances are stored for a long time under normal working conditions (Lei Xiaofan, 2010). Class 1 Hazardous Area refers to the flammable and explosive substances that may exist in the system or operation area or contact with the air under normal working conditions. Class 2 Hazardous Area refers to the area where hazardous substances will be stored in a short time under special working conditions (such as oil loading and unloading conditions of oil tankers) or in case of failure. Generally, Class 0 Hazardous Area and class 1 hazardous area are the key research objects.

Table 4.1 Types and characteristics of fire and explosion

Name	Characteristic
Jet fire	Once the oil-gas mixture leaks, it is prone to fire and explosion, just like the flamethrower.
Flash fire	Oil and gas begin to burn from the place far away from the leakage source, and generally spread rapidly from the edge to the whole leakage area.
Oil pool fire	Oil pool fires may occur in a wide range of areas. As long as the process unit contains crude oil, they are in danger. The biggest feature of oil pool fires is that they produce toxic and harmful substances and smoke, which pose a great threat to rescue and personnel evacuation.
Ball fire	In case of continuous leakage from the pool leakage source, the continuous oil and gas will be ignited in an instant in the form of a ball of fire.
Vapor cloud explosion	Vapor cloud explosion is a more violent type of explosion, when the leakage of combustible gases in a larger space, or temporarily did not cause ignition explosion, the gas continues to spread, and air to form an explosive mixture, once ignited, will occur on a wide range of violent explosion, the explosion will produce a strong shock wave, the impact of a large area, the surrounding personnel and equipment to cause injury

4.1.3 Fire and explosion prevention measures for platform

As the platform is on the sea and exposed to wind and sun all the year round, it is easy to cause fire and explosion. We should pay attention to the area, maintenance and overhaul of equipment at all times. For some high-pressure equipment, pressure checks should be done regularly and pressure relief should be carried out when the pressure is too high (Lei, 2010). Secondly, the operation of oil testing equipment will be accompanied by a large amount of oil and gas generation, so it is necessary to regularly check whether there is any oil and gas leakage at the equipment connection, especially for equipment whose operating pressure is greater than the external air pressure; static electricity is also a factor that causes fire and explosion in equipment, so the system must have static electricity protection devices, and the operator must dress according to the regulations.

Table 4.2 Checklist of measures taken

Measures to be taken	OIM	Maintenance supervision	Captain	Personnel on duty	Agent	Reference
Report accident (internal)				★		
Report to platform staff and other nearby platforms	★		★	★		
Adjusting the platform's heading and speed	★		★	★		
Implement emergency response procedures	★					
Begin reporting to the company and agents	★					
Organize platform staff to rescue and strive to control the fire	★	★	★			
Probing the fire and identifying the cause of the fire		★	★	★		
Disconnect fuel lines and circuits to the fire compartment		★				
Close the watertight doors and windows of the fire compartment		★	★	★		
Evaluate the possibility of pollution caused by oil spill	★	★	★			
Start to remove oil spills and implement containment	★	★	★	★		

Decide whether to transfer fuel on board	★					
Contact shore rescue support (if required)	★				★	

In addition, we should strengthen the basic technical literacy and professionalism of the work management personnel on the platform, and treat the work seriously and responsibly without any carelessness; Strengthen the safety training and safety awareness of personnel, strengthen the patrol inspection, work in strict accordance with the operating procedures, and prohibit the fatigue of personnel. At the same time, the platform safety system shall be established, and detectors shall be installed in the operation area. When flammable and explosive gases exceed a certain concentration, the detectors will alarm. In addition, a certain number of fire extinguishers shall be equipped on the platform. See Table 4.2 for the checklist of measures taken in case of fire and explosion on the platform. This table refers to the checklist of fire and explosion measures for offshore oil 982 deep-water drilling platform of COSC.

4.2 Blowout

4.2.1 Blowout accident of drilling platform

On June 3, 1979, during the operation of Medco 135 semi-submersible drilling platform leased by Mexico Oil Company, it encountered a soft rock stratum at 3600m of the seabed, and the drilling fluid leaked, resulting in the loss of hydrostatic pressure. Mexicanos planned to move out the drill bit and pump drilling fluid along the open drill pipe to seal the formation fractures. But during the process of moving out the pipe, a blowout occurred, nonetheless, as the drill ring and blowout preventer were set together, and the blowout preventer gate could not cut through the thick steel wall on the drill ring, resulting in a large amount of crude oil leakage, creating a 261km contamination zone and serious pollution to the environment. The Deepwater Horizon rig explosion in the Gulf of Mexico on 20 April 2010, mentioned above, caused serious pollution to the marine environment and went down in history as the largest offshore oil accident, with well blowouts being the main cause (Liu Xiuquan et al., 2013).。

4.2.2 Blowout accident analysis

The leakage of crude oil during drilling is mainly caused by blowout or non-surge during drilling. During oil drilling operation, well control is implemented by ensuring that the pressure of drilling fluid column is greater than the bottom pressure. Once the formation pressure is greater than the drilling hydraulic pressure, the formation fluid will flow into the well and produce kick (Lei Xiaofan, 2010). Furthermore, when the drilling fluid and surface equipment are out of control, the kick may become blowout or even explode, resulting in crude oil leakage. Blowout accidents of drilling platform mainly occur in shallow gas layer and high-pressure formation.

4.2.3 Preventive Measure

By understanding the blowout accident and the analyzing the blowout accident on the drilling platform, it can be seen that the prevention of the blowout accident is important. Improve the equipment management system, each work has a detailed division of labor procedure, and the equipment management of offshore oil drilling platform should establish a reasonable safety system. At present, some offshore drilling platforms do not reasonably allocate the tasks of technicians and staff, and lack a reasonable safety management system. Improving the safety system of drilling platforms can reduce the probability of blowout. The rig needs to write a complete safety and risk assessment report based on the type of project and risk factors, prepare a program, judge and draw up solutions, improve the safety assessment mechanism and feed the report back to the relevant government departments for inspection. Implement the responsibilities of each staff member in the operation process, including platform design, equipment selection, equipment operation, etc., and clarify the actual tasks and responsibilities of each department according to different operation status, such as joint operation, drilling construction, etc. It should be specific to each department and each staff member to ensure the smooth operation of daily work, avoid panic when dealing with emergencies, and handle safety accidents with ease.

Safety accidents are unavoidable for the offshore oil industry, and the causes of major accidents are accumulated gradually. Figure 4.2 illustrates the causes of major accidents. In order to effectively reduce accidents, improve the quality of equipment management of offshore drilling platforms, and improve oil production efficiency, relevant technicians of offshore oil drilling platforms should conduct analysis and research according to the characteristics of the platform itself or the schemes of other drilling platforms. And build a scientific and reasonable accident early warning scheme to reduce the probability of accidents. Regular drills for unexpected accidents should be carried out, as accidents themselves cannot be reversed, but can only be prevented to eliminate their frequent occurrence. Drills can solve the actual problems and defects, enhance the coordination and resilience of the whole team, effectively improve the efficiency of handling accidents and ensure the smooth running of rig extraction.

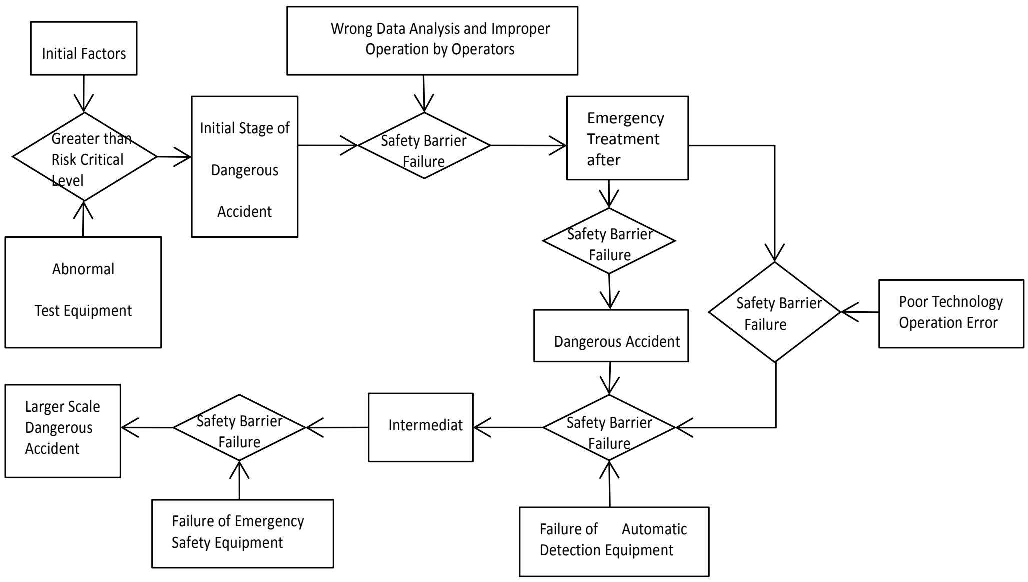

Figure 4.2 Causes of major accidents

4.3 Collision

4.3.1 Drilling platform collision accident

In 2002, WEN13-1 jacket platform was impacted by a nearby large pipe-laying crane during construction, causing serious economic losses and casualties (Liu Yang, 2017).

On march7, 2004, "Far Symphony" collided with "West Venturesemi" (Kvitrud, 2011).

On October 27, 2020, the "Da Yang Topaz" broke its anchor chain due to bad weather and collided with the Malaysian national oil Baram oil platform located at about 7.7 nautical miles in the South China Sea of Merigualabar. 125 of the 187 crew members on board jumped into the sea to escape, and 62 crew members remained on board.

Two of the crewmembers died.

4.3.2 Drilling rig collision analysis

Due to the negligence of operation or the occurrence of unexpected accidents, ships may collide with the offshore platform structure, and the superstructure of the platform may drop heavy objects, etc. Collision often causes overall bending and local depression of platform structural members, reduces the bearing capacity, affects the safety of members, and sometimes greatly weakens the strength of the whole platform structure (Zhu Mengwei, 2006). Ships that collide with the platform mainly include the following categories: ships sailing on the normal route, such as passing merchant ships; Ships sailing on non-route passage, such as fishing boats; Platform supply vessel; Guard ship (Guo Shichen, 2015).

Since 1980, 6 platforms have been completely damaged due to collision or contact (Sun yanjie, Li liangbi, & Yin Qun, 2007). Causes of collision: when the platform objects are transferred, they fall onto the platform and collide with the ship near the platform, accounting for 75% of the reported accidents.

The main causes of accidents can be divided into the following five categories：

- Misjudgment of ship drivers -- the main cause of accidents.
- Equipment failure - such as ship power failure or dynamic positioning failure.
- Weather - for example, the ship drifts and collides with the platform due to rough sea.
- Mooring system problems - fouling of anchors or mooring lines or dragging delays;
- Others - rare or unique causes, different from the above classification (Zhu Mengwei, 2006).

Among the reasons above, 46% of the accidents are caused by the wrong judgment of ship drivers, and most of them will cause serious damage to the platform. Bad weather is also one of the main causes of collision. This article 4.4 will describe the impact of bad weather on the drilling platform. However, usually these accidents do not cause serious structural damage to the platform.

4.3.3 Preventive Measure

In order to prevent collision, the distribution of platform position information should be improved first. The ship arranges the route in advance to avoid collision and warn approaching ships. When the ship is 55~75km away from the platform, radar monitoring and radio call shall be used to warn the incoming ship to avoid collision. Set up anti-collision system. The use of different forms of anti-collision facilities can prevent the ship's impact force from directly acting on the offshore platform structure, or extend the ship's collision time by cushioning and energy dissipation, reduce the ship's impact force and protect the safety of the jacket structure.

Table 4.3 Checklist of measures taken

Measures to be taken	OIM	Maintenance supervision	Captain	Personnel on duty	Agent	Reference
Report accident (internal)				★		
Report to platform staff and other nearby platforms	★		★	★		
Implement emergency response procedures	★					
Begin reporting to the company and agents	★					
Probing for platform damage	★		★	★		
Measure all compartments to see if water is coming in		★	★			
Find out the position of the breach and the degree of damage		★	★			
Take control measures such as plugging and drainage		★	★	★		
Decide whether to transfer fuel on board	★					
Start to remove oil spills and implement containment	★	★	★	★		
Decide whether shore	★				★	

rescue support is required						

Table 4.3 is the checklist of measures taken in case of collision between the platform and the ship. This table refers to the checklist of fire and explosion measures for offshore oil 982 deep-water drilling platform of COSC.

4.4 Extreme weather

4.4.1 Examples of extreme weather at sea

In 1969, the Bohai Sea was severely frozen, resulting in the "HAI-2 well" living platform, equipment platform and drilling platform being pushed down by the sea ice, and the "HAI-1 well" platform support brace being cut off by the sea ice (Yuan Benkun et al, 2018). On 25 October 1983, the Javanese Sea Drillship was operating in the Inge Sea when it capsized and sank in a strong typhoon No. 16, killing all 81 people on board. The accident was caused by the carelessness and inappropriate command of the captain of the drill ship, who failed to evacuate in time when he knew that the strong typhoon was about to reach the drill ship's work area but ordered the ship to continue its operations, eventually causing the platform to sink. On 18 December 2011, the Russian offshore oilrig "Kolskoye", located in the center of the Sea of Okhotsk, 200km off the coast of Sakhalin Island, was hit by a storm, which broke the windows and facilities on the platform and caused the platform to sink due to the rapid influx of seawater. Four people were dead and 49 were missing because of the accident.

4.4.2 Analysis of bad weather and sea waves at sea

Offshore extreme weather will affect offshore drilling platforms, mainly including typhoon and sea ice.

- Typhoon

The main hazard factors of typhoon are strong wind, rainstorm, huge wave (surge) and storm surge. The factors that directly affect the offshore oil platform are mainly strong winds and huge waves (surges). The huge wind pressure generated by strong winds will cause pressure imbalance on the windward and leeward surfaces of the offshore platform, resulting in the risk of violent shaking or even overturning. The huge waves (surges) have a frequent and instantaneous impact on the offshore platform, resulting in damage to the platform itself or equipment and facilities, or even significant displacement. The comprehensive effect of these hazard factors will often bring serious harm or disastrous consequences to platform production and personnel safety. Typhoon hazards should be paid attention by offshore oilfield companies in terms of risk identification and response, given the hazards of typhoons to offshore oil platforms and their sudden and devastating nature.

The spatial distance is used as the basis for the corresponding risk level to divide the typhoon emergency alert area. For example, the main consideration of an offshore oil platform is the spatial distance between the typhoon and the platform or the time when the periphery of a certain level of typhoon wind circle reaches the platform position. Usually the platform operation well position is the centre of the circle, the distance from the periphery of tropical cyclone 8 wind circle to the platform position as the radius, divided from outside to inside into green, yellow, orange, red concentric circles of Typhoon emergency alert areas (see Figure 4.3). Some companies quantify the radius of each alert zone as fixed, i.e. strictly its radius size and interval. In fact, from a safety and efficiency point of view, the size of the radius should not be fixed, but should be determined by a combination of factors such as the speed of movement of the tropical cyclone (typhoon) and the time required to affect evacuation of personnel and equipment.

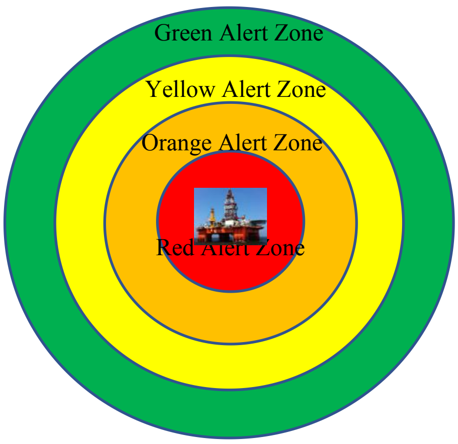

Figure 4.3 Diagram of the typhoon warning circle

Red alert zone: its radius generally refers to the safety margin after all personnel and key equipment to be evacuated the platform. The safety margin shall be at least 24 hours (1 day). If the moving speed of tropical cyclone (typhoon) is 10 km / h, the radius shall be 240 km.

Orange alert zone: the difference between the inner and outer diameter of its circle (orange part) is the time required to evacuate the entire operating personnel and critical equipment of an offshore facility, which is determined by the number of personnel working at the facility and the number of evacuation tools (e.g. ships, platforms), as well as their performance and efficiency. If it takes 10 hours to evacuate the entire personnel and critical equipment of an offshore oil platform, and the typhoon moves at 10 km/h, the length of its environment (orange) is 100 km.

Yellow alert zone: The difference between the inner and outer diameter of its ring (yellow part) is the time required for the safe disposal of an offshore oil platform against typhoons from the cessation of production operations to the completion of evacuation, the size of which is determined by its construction process, nature and current operational status. If this process takes 48 hours and the typhoon moves at a speed of 10 km/h, the length of its ring diameter (yellow) is 480 km.

Green alert zone: The radius of its circle (green part) is the tracking and attention phase, which is generally the distance from the location of the start of the generation of a tropical cyclone (and forecast to affect the sea near where the offshore facilities are located in the future) to the outer edge of the yellow alert circle, which is determined by the location of the generation of the typhoon (international start of naming and tracking start) from the platform well position.

- Sea Ice

Sea ice can be divided into two moving states: fixed ice and drift ice. Fixed ice can push ships to run aground or freeze them, or even squeeze marine facilities to cause them to break and be flooded; Drift ice floats on the sea surface and drifts around with the sea wind and current. In the process of drifting, it may collide with ships or marine facilities, resulting in hull deformation, facilities being pushed down and other similar accidents. Sea ice mainly affects the pile legs and submersible pump towers of drilling platforms. Jack-up drilling platforms are usually composed of three or four pile legs, including two types: column and truss. Generally, jack up drilling platforms are designed to operate in ice-free areas. However, due to the operation needs or delayed evacuation, the platform is affected by drift ice, which mainly affects the platform pile legs and submersible pump tower. In the early stage of China's offshore oil development, due to the lack of understanding of the impact of sea ice and the serious ice situation at that time, the production equipment and drilling platforms of "Hai 2 well" and "Hai 4 well" were pushed down by sea ice. With the development of China's offshore oil drilling business, the understanding of sea ice has gradually deepened and countermeasures have been gradually improved, with few major sea ice impact accidents occurring, but there are still times when sea ice impacts are dangerous, especially the impact of sea ice on the rig's seawater pump tower. Jack-up rigs are generally equipped with a seawater pump tower system to provide equipment cooling, ballast, drilling and completion production, and domestic sanitary seawater, and are generally available as stand-alone lifts or as crane lifts with pile legs (Chen Aiguo et al, 2016). When the platform is affected by sea ice, the submersible pump tower is prone to fracture due to its weak structure, which directly affects the production of the platform. In serious cases, the generator unit is shut down at high temperature and the whole ship is powered off.

4.4.3 Preventive measure

- Typhoon

Accurate information on weather and sea conditions is key to organizing and implementing typhoon contingency operations, and it is not always necessary to organize a full or partial evacuation when a typhoon affects an offshore oilfield company. Unnecessary evacuations, especially during the typhoon season, will only result in additional production delays and evacuation costs. Of course, they may expect a fluke, which leads to safety hazard and serious consequences due to miscalculation. When a typhoon is approaching, the emergency headquarters must make a comprehensive analysis based on the predicted intensity, moving path and the possible impact of future development trend on the relevant sea areas, combined with the wind resistance design, performance status, sea area location, hydrological conditions and other factors of the offshore facilities, and finally make a scientific decision on when to evacuate all or part of the personnel from the platform. With the rapid development of satellite, remote sensing and other high technologies, people observe and send back a large number of pictures and data to the ground day and night through meteorological satellites, which has unprecedentedly improved the ability of human beings to understand the weather. The continuous, realistic, vivid and intuitive satellite cloud maps have shown great superiority in monitoring the movement path and intensity changes of offshore typhoons, providing a reliable scientific basis for the effective implementation of emergency operations against typhoons on offshore oil platforms. Specific measures to enhance China's sea ice disaster prevention and mitigation capabilities include basic information acquisition, sea ice warning and reporting services, sea ice defense systems, sea ice disaster risk assessment and zoning, sea ice disaster damage assessment, sea ice disaster emergency plans, and publicity and education.

- Sea Ice

Acquisition of basic data: basic data is the basis of sea ice disaster prevention and reduction. Therefore, the ability and technical level of basic data acquisition should be continuously improved. Basic data shall be obtained through sea ice monitoring and historical data collection. Sea ice monitoring methods should include monitoring shore based ocean stations, coastal patrol, satellite remote sensing, shore based radar (including vehicle mounted radar), aviation, ships and offshore platforms. At the same time, the research and development of advanced sea ice monitoring technology should be strengthened, and foreign advanced technology and equipment should be introduced in time.

Sea ice early warning and reporting services: Years of practice has shown that sea ice forecasting and sea ice disaster early warning can enable governments at all levels, enterprises (enterprises) and the public to understand and grasp information on changes in ice conditions in a timely manner, and provide governments at all levels with a basis for decision-making on sea ice disaster prevention and mitigation. Therefore, it is necessary to effectively strengthen the capacity of sea ice forecasting and sea ice disaster warning, especially to effectively enhance the capacity and technical level of small area and fine sea ice warning.

Sea ice defense system: Firstly, a certain number of icebreakers should be built to strengthen prevention and carry out emergency work. Secondly, research on the physical and mechanical properties of sea ice should be carried out to provide reasonable design parameters for sea ice loads for the anti-icing capacity of marine engineering buildings. Thirdly, safety management of winter production operations in icing sea areas should be strengthened to prevent disasters before they occur: in addition, the sea ice disaster emergency command system and in addition, the administrative management system for daily defense against sea-ice disasters should be further improved.

4.5 Emergency response

Maritime emergency response mainly focuses on the rescue and oil spill disposal measures required by ships and other accidents at sea. China established the national inter-ministerial joint conference system for marine search and rescue and the national inter-ministerial joint conference system for major marine oil spill emergency response in 2015 and 2012, respectively. Its sub-office, China Maritime Search and Rescue Centre (China Maritime Oil Spill Emergency Response Centre was established) is responsible for the emergency response to emergencies at sea. Under the China Maritime Search and rescue center, there are provincial search and rescue centers and search and rescue sub centers, which take actions according to the risk level (Table 4.4) and emergency response level (Table 4.5). At present, China has not set up an oil spill emergency response center at or the provincial level below, which is implemented by the search and rescue center in the actual disposal (Fan Tianji, 2021).

Table 4.4 Danger level

Name	Standard
General dangerous situation	Dangerous situations where there are less than 30 persons in distress on board: Collision, reefing, fire, etc. of non-passenger vessels of less than 3,000 gross tons that pose a threat to the safety of the vessel and its personnel: Oil spill from a ship of less than 10 tons: Waterborne hazards causing or likely to cause general hazards.
Major dangerous situation	In the event of distress on board a ship with 30 or more persons and less than 50 persons: Any passenger ship in serious danger to the life of the ship and its personnel: In the event of collision, reefing, fire, etc. on board a vessel of 3000 GT or more and less than 10000 GT, which poses a threat to the life of the vessel and its personnel: Oil spill from a ship of 10 tons or more and less than 50 tons: Missing Chinese vessels or foreign vessels with Chinese crew Other dangerous situations that cause or may cause a large social impact.
Extremely dangerous	In case of distress on board a vessel with more than 50 persons or more: Any passenger ship in distress where it is uncertain whether the number of persons in

situation	distress exceeds 50 or more; In the event of a collision, pestle or fire involving a ship of 10,000 gross tons or more, which poses a threat to the life of the ship and its personnel: Oil spills of 50 tons or more: Any other hazard causing or likely to cause significant social impact.

Table 4.5 Emergency response level

Name	Standard
Level IV response	Marine emergencies causing less than 3 deaths (including missing): Marine emergencies endangering the lives of less than 3 persons: Marine emergencies that pose a threat to the life of the ship and its personnel, such as collisions, pestles, fires, etc., on non-passenger ships and non-hazardous chemical ships under 500 gross: Other maritime emergencies causing general hazards and consequences.
Level III response	Marine emergencies resulting in the death of more than 3 persons and less than 10 persons (including missing): Marine emergencies endangering the lives of more than 3 persons and less than 10 persons: Marine emergencies that threaten the lives of ships and personnel, such as collisions, pestles, fires, etc., on non-passenger ships of more than 500 gross tons and less than 3,000 gross tons, or on non-dangerous chemical ships Disappearance of a Chinese ship or a foreign ship with Chinese crew: Maritime security incidents that endanger the lives of more than 3 persons or less than 10 persons: Other maritime emergencies that have a large social impact.
Level II response	Marine emergencies causing more than 10 and less than 30 deaths (including missing): A maritime emergency that endangers the lives of more than 10 persons and less than 30 persons: Civil aircraft with less than 30 persons on board in an emergency at sea:

	A maritime emergency that threatens the safety of the ship and its personnel, such as collision, reefing, fire, etc., on a non-passenger ship or a non-hazardous chemical ship of more than 3,000 gross tons or less than 10,000 gross tons: Maritime security incidents endangering the lives of more than 10 persons and less than 30 persons: Other maritime emergencies causing serious harm, social impact and international influence
Level I response	Marine emergencies causing more than 30 deaths (including missing): Marine emergencies endangering the lives of more than 30 people: A maritime emergency on board a passenger ship or chemical tanker that seriously endangers the life of the ship or its personnel: A civil aircraft with more than 30 passengers on board has an emergency at sea: Collision, pestle, fire or other maritime emergencies that threaten the safety of ships and personnel: A maritime security incident that endangers the lives of more than 30 people: Maritime emergencies requiring the State Council to coordinate with relevant regions, departments or the military to organize rescue operations Other maritime emergencies causing particularly serious harm and social impact.

Marine pollution has the characteristics of difficult cleaning, great harm and large space pollution area. Therefore, how to treat marine oil pollution has always been a very difficult problem. For the cleaning of oil pollution, China classifies different dangerous situations and takes corresponding measures for marine emergency rescue. How to clean marine oil and prevent the spillage of offshore drilling platforms has become a key issue that needs our attention.

CHAPTER 5

Pollution management and emergency policies

5.1 Introductory domestic pollution management and emergency measures

The regulations of the people's Republic of China on the administration of environmental protection for offshore oil exploration and development was promulgated by the State Council on December 291983 in order to prevent pollution damage to the marine environment. It has played an important role in preventing pollution from offshore oil exploration and development and protecting the marine environment and resources. With the development of economy and society, some provisions of the current regulations are no longer suitable for the needs of marine environmental protection, so it is necessary to revise and improve them. Firstly, due to the increase in marine development, the interaction between marine oil exploration and development and other development activities has become increasingly close. And it is necessary to further clarify the environmental protection responsibilities of exploration and development developers and establish a sound environmental protection responsibility system for marine oil exploration and development while strengthening the government's regulatory responsibilities. Secondly, the current regulations provide for a relatively principled system of pollution prevention and control. It is necessary to refine and strengthen the pollution prevention and control measures for offshore oil exploration and development based on practical experience. Thirdly, the existing regulations lack specific provisions on emergency preparedness, emergency response, accident investigation and other emergency disposal for oil spill pollution accidents. Fourthly, the existing regulations have a single form of punishment and are not strong enough to investigate violations. It is necessary to implement the relevant provisions of the amended Marine Environmental Protection Law and the Environmental Impact Assessment Law, and to increase the penalties such as continuous daily fines, ordering the suspension of production and rectification or ordering the suspension of business or closure (State Oceanic Administration, 1989).

In order to solve these problems, the State Oceanic Administration drafted the regulations of the People’s Republic of China on the administration of environmental protection for offshore oil exploration and development (Revised Draft for examination) and submitted it to the State Council for approval. The requirements for modifying the main contents are as follows:

- Strengthen supervision and management

First, the exploration developers' responsibility for the environmental protection should be strengthened. They should regard the protection of the marine environment as the legal obligation of exploration developers. The exploration developers are explicitly required to prepare the environmental impact statement (table) before the commencement of the construction project and the approval relationship between investment approval and environmental impact statement (table) is changed from "series" to "parallel". Second, public participation should be increased. It is stipulated that except for matters involving state secrets, the preparation of the environmental impact statement shall be announced to the public and the opinions of the public and interested parties shall be fully solicited; when examining the environmental impact statement, the competent department shall further listen to the opinions through public consultation, holding hearings and other forms. Third, strengthen the supervision responsibilities and measures of the competent departments. Implement the total amount control system for pollutant discharge in key sea areas, and implement the environmental assessment and approval restriction system for sea areas exceeding the standard; the competent authorities are required to strengthen supervision and inspection and stop illegal acts that pollute the environment in a timely manner. Refine pollution control measures.

- Refine pollution control measures

First, the government should improve the basic requirements for pollution prevention and control. Exploration developers should be required to establish an environmental protection responsibility system and give priority to energy-saving and environmental protection processes, equipment and technologies. Exploration developers should be equipped with corresponding environmental protection facilities. It is prohibited to discharge pollutants through abnormal operation of environmental protection facilities or falsification or falsification of monitoring data. The second is to refine the specific system of pollutant discharge and disposal. For different kinds of pollutants such as industrial waste, domestic waste, drilling fluid, oily sewage and thermal waste water, management measures such as prohibiting discharge into the sea, transporting them back to land for disposal, discharging only after reaching the standard, crushing treatment, etc. are specified according to their hazard degree and characteristics. Third, increase relevant environmental protection requirements during and after exploration and development. Require exploration developers to regularly submit anti-pollution records to the competent authorities during the operation. After the operation is terminated, the exploration developer shall timely deal with the relevant facilities and organize the implementation of environmental restoration and treatment measures according to law.

- Establish and improve the emergency disposal system for oil spill pollution accidents

Firstly, we should improve the oil spill pollution accident prevention system. The competent department is required to formulate emergency plans, and the exploration developer is required to formulate corresponding emergency plans, define corresponding early warning, reporting and disposal plans, implement responsible personnel, and provide emergency equipment and materials. Secondly, establish an emergency response mechanism for oil spill pollution accidents. It is stipulated that after an oil spill pollution accident occurs, the exploration developer shall immediately control the oil spill source and take measures to recover the oil, and report to the competent department and the relevant local government at the same time. If the exploration developer's emergency response is not effective, the competent department shall directly organize on-site emergency response or designate a third person to handle it. Other departments shall carry out corresponding emergency disposal according to their responsibilities. Thirdly, the follow-up disposal mechanism for oil spill pollution accidents should be improved. The classification standard of pollution and oil spill accidents should be defined and the corresponding accident investigation, information disclosure and other systems should be improved.

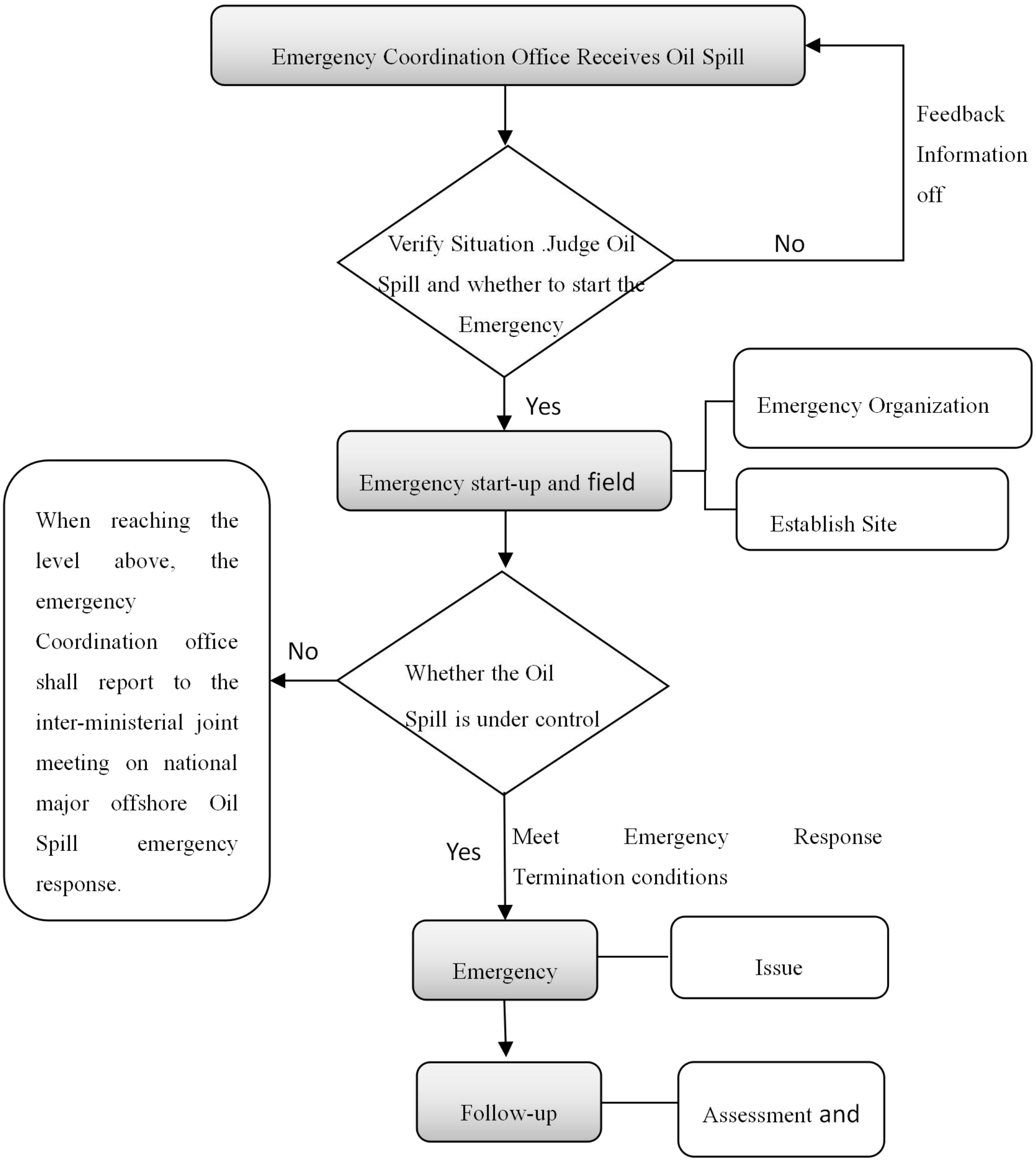

Figure 5.1 Emergency response flow chart

（4）Strict legal responsibility

While strengthening the accountability mechanism for the competent departments and their responsible personnel, we have comprehensively revised the relevant legal liability provisions, increased the amount of fines, increased the number of punishment and mandatory measures such as daily continuous punishment, ordering the suspension of production for rectification, or ordering the suspension of business, closure, and third-party performance, focusing on stopping and correcting illegal acts(Ministry of transport, 2018). The basic flow of emergency measures is receiving an alarm, assessing the response level, emergency activation, emergency action, judging whether the situation is expanding, emergency termination and follow-up (State Oceanic Administration, 2015; Ministry of Transport and National Development and Reform Commission, 2016) (Figure 5.1).

5.2 US offshore drilling management regulations and emergency report

- Regulatory Act

The main legislation of the U.S. offshore oil and gas industry is the Outer Continental Shelf Lands Act (OCSLA), which includes specific provisions on the management and supervision of U.S. resource development beyond the jurisdiction of each state.。

The OCSLA authorizes the U.S. Department of the interior (DOI) and the U.S. Coast Guard (USCG) to formulate and implement regulations related to economic activities in coastal and coastal areas of each state. It defines the responsibility of DOI to manage the exploration and development of mineral resources within the federal jurisdiction, to manage the balanced development of offshore oil and gas resources and protect the human, marine and coastal environment. In addition, there are some generally applicable laws, regulations, and provisions for specific issues, including specific laws and regulations, such as environmental protection, navigation safety and oil pollution prevention, which are applicable to the supervision of other industrial and marine activities (Jennifer Dagg et al, 2011).

- Supervisory System

The U.S. regulatory system is that DOI entrusted its regulatory power to the relevant subsidiary regulatory bodies of offshore energy. Due to the Deepwater Horizon blowout accident in the Gulf of Mexico in the spring of 2010, these subsidiary bodies are still being rebuilt. In the spring of 2010, DOI entrusted its responsibilities in offshore energy to the mineral management service (MSS), which is responsible for managing the three main administrative functions related to offshore energy: (1) evaluation Planning and leasing offshore oil and gas resources; (2) Implement environmental and safety regulations; (3) Revenues from the collection of royalties and the management of energy activities. In may2010, DOI separated these three functions to ensure the independence of their respective management, and finally managed by the new subsidiary. DOI created the marine energy management regulatory and Enforcement Agency (BOEMRE) and transferred all responsibilities of

MMS to BOEMRE as a temporary settlement for reorganization and eventual separation of responsibilities. The Environmental Protection Agency (EPA) and the USCG also have responsibilities related to certain target regulations. The Environmental Protection Agency (EPA) and the U.S. Coast Guard (USCG) are also responsible for certain targeted specific regulations related to environmental and safety regulations. However, the regulatory authorities of these regulations coincide with BOEMRE's OCSLA. In order to solve this problem and avoid regulatory duplication, the three agencies have signed agreements to determine independent jurisdiction responsibilities, although sometimes there is still overlap. An important example is the 1994 Memorandum of Understanding (MOU) which established "responsibilities relating to oil spill prevention and control, response planning and inspection of response equipment". The MOU assigned responsibility for offshore installations located within the coastline to MMS (now BOEMRE).The USCG also has a number of regulations relating to maritime safety, emergency preparedness and incident response, as well as regulations specific to mobile offshore rigs (MODUs).At the same time, the US EPA has a number of relevant government emergency plans and cooperative response plans related to oil spills and disasters.

- Supervision mode

The regulatory system in the United States is mainly normative, which stipulates the exact requirements that offshore facility operators must meet. If the regulatory provisions do not specify the technical requirements, they will usually be "incorporated" into the industry standards. On 14 October 2010, BOEMRE issued a provisional rule on normative safety measures for well control and implemented a new safety and environmental management system (SEMs). Although the new SEMS requirements leave the main responsibility for the implementation and supervision of SEMs to operators, it specifies the elements of the operators' SEMS plan in detail, rather than simply setting the objectives of this plan.

- Emergency report

The lessee must include prescribed procedures in its SEMS, which must include an emergency action plan that assigns authority and responsibility to qualified personnel to initiate effective emergency response and control; compliance with all applicable government regulations when dealing with emergency reporting and emergency response; and each emergency control center should have access to emergency action plans, oil spill response plans and other safety and environmental related information. Training and drills, which include emergency response and evacuation procedures, are to be conducted in accordance with the requirements of the SEMS Training Plan and are to be conducted regularly for all personnel (including contractors). Drills must be conducted on a practical basis and on a regular basis, rehearsing the required elements of the emergency action plan. Each exercise must also be analyzed and commented on in order to identify and correct weaknesses. These provisions differ from those in the Canadian offshore Arctic in that they do not specify the requirements for means of protection of life and countermeasures to contain pollution.

5.3 UK offshore drilling management regulations and emergency report

- Regulatory Act

In the UK, the central piece of legislation governing the offshore oil and gas sector is the Petroleum Act 1998. This Act of Parliament regulates the development of the UK continental shelf. The continental shelf is located in the North Sea off the eastern coast of the UK and it contains the majority of the UK's oil reserves. The petroleum Act 1998 empowers the Department of energy and climate change (DECC) and the health and Safety Executive Committee (U.K. HSE) to develop and implement key regulations for oil and gas development activities. In particular, DECC is responsible for issuing licenses to explore and develop oil and gas, while the UK HSE offshore department is responsible for monitoring hazardous health risks and managing hazardous risks to health, safety and environment caused by offshore oil and gas work activities. The Maritime and Coastguard Agency is the UK authority responsible for oil spill response and planning, although they have delegated regulatory functions for offshore oil and gas installations to DECC. In the UK, many laws and regulations have regulatory provisions for specific issues; including laws and regulations aimed at environmental protection, work safety and pollution prevention. It should be noted that as part of the European community, Britain must comply with European legislation. The UK is a party to the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention), which sets out the precautionary principle, the principle of payment for pollution, oil and gas regime. For example, the UK and Norway have neighboring jurisdictions in the North Sea. At the time of writing, the OSPAR Commission was awaiting the results of national reviews of regulations following the Gulf of Mexico oil spill before proposing any new measures.

- Supervisory System

Britain's health and safety system has undergone fundamental changes since the Piper Alpha disaster in 1988 that 167 people were killed in the disaster. One of the most significant changes is the removal of responsibility for enforcing safety standards from the licensing and development agencies, a change made in response to recommendations in the public inquiry into the Piper Alpha disaster. The basis of the Callan report was that the recommendations were based on the conclusion that having one body responsible for overseeing production and safety could create conflicts. The parliamentary Act stipulates that the UK regulatory system consist of a series of instruments. The parliamentary Act provides a framework and provides ministers with the power to regulate specific activities. Rules and regulations are regulations derived from these acts and provide more details of requirements. HSE in the UK also provides guidance where it believes that regulations cannot be justified.

- Supervision mode

The UK HSE currently uses a target-setting or performance-based approach to safety and environmental regulation. Operating companies are required to demonstrate to the HSE that they are taking positive steps to minimize the risk of health and environmental hazards. In a regulatory system such as the UK's, regulators must ensure that operators and government have the same risk precautions and do not expose people and the environment to unacceptable levels of risk. It is also important to take into account the variability of the hazards, which means that the measures required may vary from place to place. The government explained that it hoped that operators would adopt "good practices", provide guidelines, and come up with codes of practice to illustrate this. It can be seen that in the UK regulatory system, many regulators are based on "good practices". In the UK regulatory system, the responsible person has the responsibility to prove that no matter what regulation (procedure, standard, system or hardware) can meet the objectives are all required in the regulations.

- Emergency report

OSCR pointed out that safety cases need to include an appropriate emergency management system. This requirement not only makes HSE in the UK believe that the responsible person has the ability and means to effectively control major accident risks, but also provides an additional regulatory control in addition to PFEER and DCR regulations. For example, there must be management arrangements for evacuation, escape and rescue in case of emergency. PFEER requires that measures be taken to prevent fire and explosion at offshore facilities and protect people from the effects of fire and explosion. Organizations and arrangements to meet these requirements organizations and arrangements to meet these requirements will form part of the management system in the safety case. According to Article 12 (1) (a) of OSCR, for the purpose of safety case demonstration, there is no difference between these regulations in the United Kingdom and those in the Canadian Arctic offshore.

5.4 Canadian Arctic maritime regulation and emergency report

- Regulatory Act

The main legislation for offshore oil and gas in the Canadian Arctic is the Canadian Oil and Gas Operations Act 16 (COGOA), which regulates the exploration of resources and the operation of offshore activities. COGOA specifies the responsibilities of operators to ensure the safety of workers and protect the environment, and provides procedures for how to obtain oil well approval. At the same time, some regulations of COGOA specify the requirements for activities during oil and gas exploration and production. An oil well will not be approved until the health and safety requirements under the Canada Labor Code have been met. The Canadian Environmental Protection Act, the Canadian Environmental Assessment Act, the Emergency Response Act and the Canadian Environmental Protection Act set out specific requirements for oil spill planning and preparedness.

- Supervision mode

The National Energy Board (NEB) oversees oil and gas exploration and development in the north and offshore. NEB is responsible for evaluating the application and issuing the well authorization. In the event of an oil spill, it is the main response and coordination body. The Canadian Department of Indian and Northern Affairs (INAC) is responsible for issuing land use rights and licenses, approving or abandoning benefit plans, and collecting royalties in the Canadian Arctic region. Any areas outside of Natural Resources Canada's territorial responsibility and within federal jurisdiction are excluded from the scope of the Offshore Agreement. The administrative boundary separates the jurisdiction between INAC and NRCan, South Hampton Island and along the southern part of Baffin Island extending to the northern Labrador Sea. INAC administers the rights and royalties north of this boundary, while NRCan administers the rights and royalties south of this boundary. The Canadian Oil and Gas Drilling and Production Regulations, updated in 2009, as well as the Canadian Oil and Gas Installations Regulations, the Canadian Oil and Gas Geophysical Operations Regulations and the Canadian Oil and Gas Diving Regulations, all contain regulatory provisions.

- Emergency report

The Canadian Oil and Gas Drilling and Production Regulations require that regulatory systems must contain procedures to identify any hazards and manage associated risks. The application for authorization must contain contingency plans, emergency procedures to mitigate the effects of foreseeable events that could compromise safety or the environment. These emergency plans and procedures must include provisions for:

1) An emergency coordination plan with the relevant government.

2) Determination of the scope and periodicity of field exercises for oil spill response.

3) Training of all personnel at or entering the facility to familiarize them with safety and evacuation procedures and their responsibilities in the event of a contingency plan and emergency.

4) Adequate quantities of fuel, potable water, spill control products, safety-related chemicals, cement and other consumables are readily available for use.

5) Have appropriate equipment to provide the necessary emergency services, including rescue and first aid for all personnel. Necessary emergency services, including rescue and first aid treatment, are available for all personnel.

In addition, all safety and emergency requirements that must be met by the extraction unit are illustrated in detail in the Canadian Oil and Gas Installation Regulations.

Table 5.1 Comparison of national management systems

Regulatory topics	Canadian Arctic	America	British
Management system	Offshore operations offshore operations in the Arctic are regulated by NEB. Request for approval and force it to remain up-to-date during operation. The detailed provisions of safety and environmental protection and objective management system shall be stipulated by the regulatory authority	The regulatory body is the energy management, supervision and law enforcement department of SOA. It is required for approval, and it is mandatory to keep it updated during operation. The management system is defined by the regulatory body and is called the safety and SEMs.	The regulatory body is the UK HSE. Request for approval and force it to remain up-to-date during operation. The management system is not regulated by the regulatory authority.
Emergency preparedness	Emergency plans and emergency response procedures must be in place to deal with any foreseeable risks. Adequate measures must be taken to contain pollution.	Emergency response and contingency plans must be developed. Regular training and drills are required to respond to emergencies. The regulation does not stipulate the means to protect life and emergency measures to control pollution.	It must be demonstrated to UK HSE that the safety plan includes a comprehensive emergency and contingency plan. There must be sufficient means and emergency measures.
Emergency report	Regulators must be informed of the impact of any "accident" or "near miss" on individuals or property. Necessary procedures	It is required to regularly report all incidents with serious safety or environmental consequences to BOEMRE. It requires	The operator needs to report major incidents and emergencies. The management system must have provisions to identify and control

	for internal reporting and analysis of hazards and accidents.	that all incidents be properly and thoroughly investigated.	major accident risks.

To sum up, almost all countries of offshore oil platforms in the world have corresponding laws and regulations for supervision, emergency, prevention, etc. China's laws and regulations, the regulations of the People’s Republic of China on the administration of environmental protection for offshore oil exploration and development, are being collected and proposed to be updated. By contrast, the laws and regulations of Canada and other countries are in a relatively perfect stage, especially after the Deepwater Horizon oil spill in the United States, the supervision and corresponding preventive measures are more comprehensive. China can learn from its excellent parts to supplement the regulations of the People’s Republic of China on the administration of environmental protection for offshore oil exploration and development. In addition, the supervision of relevant departments should also be strengthened. The emergency training of offshore drilling platform personnel and the maintenance and supervision ability of equipment need to be improved.

CHAPTER 6

Summary of pollution management and pollution emergency problems and suggestions on measures

6.1 Existing problems

6.1.1 Limited resources for emergency management

Offshore oil platforms are usually far away from land, and with limited platform space, many emergency resources cannot be stored on a single platform. In the event of a safety incident, emergency resources need to be transported from neighboring platforms or from land, but the transport process is susceptible to sea conditions and weather, and there is a higher probability of delays in the supply of emergency resources. If there is bad weather in the course of emergency management in the offshore oilfield, it will be more difficult to carry out emergency response in the offshore oilfield to a large extent. Due to the special location of offshore oil platforms, it is difficult to rescue with the help of social mature fire forces in case of fire. At present, most emergency rescue work such as firefighting in offshore oil fields mainly depends on offshore staff working part-time. In case of safety accident, part-time rescue personnel shall use the existing equipment of the platform for emergency disposal. However, this process is constrained by the skills, experience and psychological quality of individual employees and the effectiveness of emergency response varies. This shows that there is a shortage of material resources and there is a large gap between human resources in offshore oilfield emergency management and professional emergency management, which reduces the level of emergency management in offshore oilfields (Zhang Ningning, 2021).

6.1.2 Lack of integration and low level of simulation in emergency drills

Emergency response plans are generally established in offshore oilfields, but the effectiveness of emergency drills carried out in accordance with the plans needs to be improved. In practice, routine, single exercises such as fire drills, platform abandonment drills and personnel overboard drills can meet the requirements. However, drills for special emergency plans such as hydrogen prevention drills, ship impact drills and chemical leakage injuries are often affected by a variety of factors, and the frequency of drills and prescribed actions do not meet the requirements. On the whole, the content of emergency drills in offshore oilfields is mostly focused on special emergency plans such as firefighting and rescue drills in which employees participate as a whole, but there is a lack of drills or guidance on special disposal plans for the team level. Moreover, the content of these drills is aimed at the initial state of the accident, which is often the trigger for the expansion of the accident. Due to the actual production conditions at the work site, the degree of simulation of the drills is low and the emergency drills carried out are used to follow a "script", which makes it difficult to simulate the complexities of an accident. On the one hand, it is difficult to raise the awareness of emergency response among operators and on the other hand, it is difficult to effectively improve the level of emergency response of emergency managers. In the actual emergency process, in case of unexpected situations and other disturbing factors, emergency managers cannot strictly follow the processes and methods stipulated in the emergency plan, which reduces the scientific and rational nature of emergency management (Zhang Ningning, 2021).

6.1.3 Maintenance records are not standardized

In the actual operation of an offshore oilrig, the probability of a safety accident also increases significantly if the staffs do not have extensive experience in operating the equipment or do not pay sufficient attention to the operation of the equipment. If the operating behavior does not meet the relevant standards, the operating process is also relatively arbitrary. This will have an impact on the safety of the operation of the equipment, thus increasing the chance of accidents (Chen Shenggen, 2021a). There are also problems with platform maintenance and documentation of equipment.

6.1.4 The Existing marine environmental protection legislation is not effective in preventing marine pollution incidents

Prevention has always been one of the basic principles of environmental protection law. The seriousness and extensiveness of the impact of marine pollution and the difficulty of cleaning it up dictate that marine environmental protection should emphasize prevention first. However, China's existing marine environmental protection legislation does not provide the principle of prevention, and only the environmental impact assessment system and the "three simultaneous" system for marine engineering and coastal engineering construction projects can play a role in preventing marine environmental pollution accidents. When an accident causes or may cause a marine environment pollution accident, the administrative counterpart shall not only be required to take immediate and effective measures to notify the potential victims in time, but also report to the department exercising the power of marine environment supervision and management in accordance with the provisions of this Law for investigation and handling. China's existing marine legislation is difficult to contain the illegal acts of the perpetrators, let alone effectively prevent the occurrence of marine environmental pollution accidents (Wang Canfa et al, 2011).

6.2 Proposition

6.2.1 Improve the equipment management system

At this stage, due to the imperfect equipment management system, individual offshore oil drilling platforms do not reasonably allocate the work tasks of ordinary staff and technicians, which affects the work quality of equipment management. Therefore, in order to strengthen the management of offshore oil drilling platform equipment, we need to improve the existing equipment management system. First, the offshore oil exploitation plan shall be prepared in combination with the actual project categories and risk factors. At the same time, we should do a good job in safety production and risk assessment, and formulate corresponding countermeasures. Secondly, the responsibilities and obligations of each staff member in platform design, equipment selection and equipment operation should be clarified, to ensure that in case of sudden accidents, they can be properly handled and solved at the first time, and provide guarantee for the stable operation of offshore oil drilling platforms.

6.2.2 Improve the professional ability of maritime emergency rescue team

The emergency management of offshore oil field requires taking effective measures to comprehensively improve the business ability of offshore emergency rescue team. The part-time rescuers lack efficient handling capacity for safety accidents, which is mainly reflected in the inability to make scientific and correct decisions in time based on the on-site situation and to take the most effective and reasonable handling measures in time, resulting in disorder and low efficiency in the whole rescue process, reducing the emergency management level of offshore oil fields. Therefore, it is necessary to pay more attention to emergency drills by offshore operators, carry out emergency drills on a regular basis as required, and improve the emergency handling ability of emergency rescue personnel under various sea conditions, bad weather and production conditions. First, in order to ensure that the emergency drill can achieve good results, corresponding drill plans should be developed based on the actual operation of offshore oil fields, and the key points of the emergency drill should be clear. Secondly, after the emergency drill, we should fully analyze and learn from the experience, constantly adjust and optimize the emergency plan, and improve the emergency rescue ability of the emergency rescue team. In addition, relevant posts shall be organized to carry out training on oil and gas firefighting, first aid and emergency command ability, and a part-time emergency team with fixed personnel, competent and well trained shall be established.

Offshore oilfield emergency response concerns all operators, so emergency management training for offshore oilfield staff should be strengthened in their daily work to raise awareness of emergency safety. In the event of a safety incident, the escape and relocation of staff is directly related to the safety of everyone's lives. However, when faced with a sudden and major accident, most people are too frightened to make the right response in time. In particular, in the event of major safety incidents such as fires and explosions, offshore staff are often overwhelmed by panic, which is not only detrimental to their own safety but also to the creation of an orderly emergency response environment. This is why emergency management in offshore oil fields should focus on improving the emergency response capabilities of staff. On the one hand, staff should be regularly educated on emergency and safety knowledge to enhance their safety awareness and emergency handling skills so that they can respond correctly in a timely manner after a safety incident. On the other hand, an emergency job responsibility system should be established to clarify the commanders, rescuers and other relevant personnel in the emergency rescue work, to ensure that all personnel can do their job in an orderly manner after a safety accident, and to promote the smooth development of emergency rescue work in offshore oil fields. In addition, new technologies should be introduced into the emergency management of offshore oil fields to improve the ability of emergency rescue and promote the development of informatization and automation of emergency management of offshore oil fields. For example, develop intelligent tracking card, improve CCTV monitoring system, fire and gas detection system, UAV and other intelligent equipment, cooperate with emergency rescue work, and improve emergency rescue capability.

6.2.3 Strengthen the risk control of offshore oil exploitation

In the process of offshore oil exploitation, workers are faced with risks such as blowout, oil and gas leakage, hydrogen sulfide poisoning and so on. In order to strengthen the management of offshore oil drilling platform equipment, we need to do a good job in daily safety management and strengthen the control of these risks. Firstly, during the operation of an offshore oilrig, oil extraction personnel must operate the equipment in strict accordance with the relevant regulations and ensure that they are licensed to do so. At the same time, corresponding risk prevention drills should be conducted to enhance the safety awareness of oil extraction personnel. Secondly, no-smoking signs should be installed on offshore oilrigs and a system should be adopted to strengthen the restraint and control of smoking behavior. If it is a fire hazard area, illegal welding and other operations are also strictly prohibited.

In offshore oil exploitation, safety accidents are difficult to avoid. Therefore, in order to significantly reduce the probability of safety accidents during the operation of offshore oil drilling platform and strengthen the equipment management of offshore oil drilling platform, it is necessary to formulate corresponding emergency plans. Firstly, technical staff should analyze the characteristics of offshore oilrigs and analyze the safety accident response plans of other offshore oilrigs, and then formulate a systematic safety accident-warning plan to reduce the probability of safety accidents. Secondly, practical drills of safety accidents should be regularly organized and carried out to find out the problems and defects in the emergency plan of safety accidents in combination with the actual drills, and take corresponding optimization measures to improve the scientific rationality of the emergency plan and strengthen the prevention of safety accidents. Finally, the coordination ability and adaptability of all staff and the handling efficiency of safety accidents should be improved to provide guarantee for the smooth progress of oil exploitation operation of offshore oil drilling platform.

6.2.4 Optimize equipment design

In order to strengthen the management of offshore oil drilling platform equipment, it is necessary to optimize the equipment design and improve the operation quality of the equipment. Compared with fresh water, seawater has strong acidity and alkalinity, and the working environment of offshore oil drilling platform is in close contact with the ocean. Therefore, the properties of seawater must be fully considered when designing equipment. For example, seawater is highly corrosive, so it is necessary to enhance the corrosion resistance of equipment during equipment design. Under the influence of ocean tide movement, some parts of offshore oil drilling platform equipment will loose and fall off during operation, which will lead to serious offshore operation accidents. In this regard, when designing the equipment, it is also necessary to focus on strengthening the vibration resistance of the equipment. In the process of equipment design, it is also necessary to carry out targeted testing of the voltage and resistance of different equipment to provide protection for the insulation performance of the equipment. Finally, in the process of designing the equipment, the focus should not only be on improving its safety performance, but also on following the principles of economy and practicality.

The marine environment is full of challenges, and the working environment of each drilling platform is very harsh. Long-term operation accelerates abnormal wear and aging of the equipment. Regular inspection and maintenance of the equipment is important as quick repairs and replacement of wearing parts can effectively reduce the long-term safety risk of the equipment. With the long-term use of the equipment, various components and the equipment itself will be worn to some extent. At this stage, the relevant equipment management personnel must design the maintenance cycle according to the harsh working conditions and the exposure of the machine. Systematic preventive scrutiny and adjustment of equipment can improve the safety performance and durability of equipment and reduce the frequency of safety incidents if each piece of equipment and test value is compared with standard values to ensure that parameters are within the standard range and that all test work is as accurate as possible (Zhao Chunyan, 2021).

6.2.5 Improvement of relevant legal systems

All kinds of problems existing in the legal mechanism of marine environmental protection in China show that China's marine environmental protection legislation urgently needs to be improved. First, the marine environment protection law should be revised, and major changes should be made in terms of principles, management systems, management systems, legal responsibilities, etc. Secondly, the regulations on the administration of environmental protection for offshore oil exploration and development issued in 1989 should be amended to strengthen the strict management of offshore oil exploration and development. Third, we should speed up the formulation of regulations such as the measures for the disclosure of marine environmental protection information, the measures for the identification and assessment of marine environmental damage, and the measures for marine environmental monitoring to serve the society. Although the perfection and perfection of laws cannot completely solve the adverse problems of marine environmental protection, a sound and perfect legal system will undoubtedly provide sufficient legal basis for marine environmental protection law enforcement and justice (Wang Canfa et al, 2011).

CHAPTER 7

Summary and Conclusions

This paper studies the safety management theory, the pollution theory of drilling platform, the theory of marine accident and the identification method of risk factors of offshore drilling operation. As offshore drilling platforms are high-risk industries that are vulnerable to many safety factors, it is very necessary to establish safety management and emergency mechanism. By comprehensively summarizing the types of pollution generated by offshore oil drilling platforms and corresponding management measures, we can fully understand the main sources of pollution generated by offshore oil drilling platforms and the main management measures adopted by platforms to deal with this pollution. Due to the offshore oil drilling platform accident, the main environmental problems are oil leakage and environmental pollution. By summarizing the main causes of the platform pollution emergency, and combining with the typical accidents that have occurred, this paper focuses on the analysis of the accidents of fire, explosion, blowout, collision and extreme weather, and defines the importance of the platform accident emergency and the effective treatment after the accident, and the necessity of establishing an emergency mechanism for offshore oil drilling platforms. It is particularly important to take reasonable prevention and emergency measures for accidents in accordance with relevant laws and regulations and relevant systems of drilling platforms. This paper introduces the relevant laws and regulations of domestic offshore oil drilling platforms and the relevant management regulations, management methods and emergency reports of offshore drilling platforms in the United States, Britain, and Canada and compares the management systems of various countries. It is found that the laws and regulations of Canada and other countries are relatively perfect , particularly， since the Deepwater Horizon oil spill occurred in the United States, it has strengthened supervision and taken more comprehensive corresponding preventive measures, China can learn from its excellent parts to supplement the existing laws and regulations. Finally, the paper summarizes the problems that still exist in pollution management and pollution emergency response, finding that the current offshore oil drilling platforms have problems such as irregular equipment operation, limited resources for emergency management, lack of comprehensive emergency drills and low level of simulation, irregular maintenance records, special operating environment. Existing legislation that cannot effectively prevent and pollution information isn't transparent. In response to the problems, recommendations were made to improve the equipment management system, enhance the operational capability of the offshore emergency rescue team, strengthen the risk control of offshore oil extraction, optimize the design of equipment and improve relevant laws and regulations. Through the research of this paper, people can realize the existing problems of pollution management and emergency response of offshore oil drilling platforms, strengthen the awareness of safety management, ensure the safety of personnel and equipment, and make the ocean cleaner.

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