Study on Spill Risk Emergency Response Framework System in the Offshore Oil Development—Taking Chengdao oil field as an example

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Abstract. Taking Chengdao oil field as an example, the establishment of spill risk emergency response framework system was discussed combined with the development of offshore oil spill risk. Based on the identification source of spill risk and the impact on the marine environment, we attempted to analyze the problem from the six aspects, including construction of the oil spill surveillance and monitoring capacities, construction of the warning capacities, construction of the command & organization & coordination mechanism, construction of the site disposal capacities, construction of the emergency guarantee linkage mechanism and construction of the environmental damage assessment. And finally, some guide was hoped to provide in the aspects of promoting the safety of offshore oil production, reducing the accident rate and improving the performance of emergency response.

1. Introduction

In recent years, some severe oil-spill pollution accidents have occurred successively at offshore oil & gas fields in our country. These accidents inevitably have continuous disruptive influence on coastal social economy and marine ecological environment as emergency response systems for oil spills are unimproved in our country. Developed countries such as the USA, Japan and UK already established and improved their respective emergency response systems for marine oil-spill pollution [1]. For example, in the United States, its emergency response systems for oil-spill pollution are divided into three levels: Level 1 is national emergency response command centers for oil spill; Level 2 is regional emergency response command centers; Level 3 is regional emergency response organizations. Once oil spill accidents happen, different competent authorities will give corresponding response respectively and fulfill their duties in the said jurisdictions, which are coordinated uniformly by national emergency response command centers for oil spill. Although emergency response systems for marine oil spill have been preliminarily built in our country, there are serious deficiencies in management systems, emergency response abilities and command and decision-marking. Therefore, in this paper, with Chengdao oil field as an example, we initially discuss the establishment of sound emergency response systems for oil spill risks in the oil field with the aim to providing instructions for promoting safe production on the onshore oil field, reducing the occurrence of accidents and improving emergency response effectiveness.
2. Method

The technical routes used in this paper take Chengdao oil field as an example and emergency response framework and systems for oil spill risks are established on the basis of determination of oil spill risk identification and influence on marine ecological environment.

2.1. Overview of Chengdao oil field

Chengdao oil field is located south of Bohai Gulf, 3km from the coast and in a water depth of 3-18m. Currently, it has four offshore operation platforms, two center platforms and one development platform; 62 undersea oil pipelines with a total length of 82.6km, one gas pipeline with a length of 11.6km, and 6 water injection pipelines with a length of 9.3km have been buried offshore, and four cluster pump stations have been built.

2.2. Oil spill risk source identification

Oil-spill risk sources are mainly divided into two categories of non-accident-specific factors and accident-specific factors. Non-accidental factors mainly focus on risk accidents caused by natural factors, including storm tide, sea ice, earthquake disaster etc., and accident-specific factors primarily focus on emergent risk accidents that occur in the process of production in the oil field, including oil well blowouts, fire, explosion, oil spills from ships and oil and gas gathering pipeline leakage etc.

2.3. Analysis of the influence of oil spills on marine ecological environment

Marine petroleum pollution can cause damage to species and imbalance in ecological system, change or destroy marine ecological system. Petroleum pollution not only can be accumulated inside the creature and transferred to advanced creatures through food chains, but also can lead to death of some creatures, like seabirds, and cause a series of reactions in the biome. Furthermore, petroleum pollution will alter changes in the concentration of some chemical substances in sea water, resulting in changes in biological behaviors [2].

3. Results and Discussion

In this paper, the emergency response framework and system for oil-spill risks in Chengdao oil field is established as follows.

![Emergency response framework and system for oil-spill risks in Chengdao oil field](image-url)
3.1. Building of oil spill monitoring and supervision capacities

Through combination of multiple mutually cooperative monitoring and supervision means such as satellite remote sensing systems for oil spill supervision, ship monitoring and supervision systems, unmanned aerial vehicle monitoring and supervision systems, real-time monitoring systems for marine environment and HD video monitoring systems, real-time monitoring and supervision, early warning of emergent accidents of marine oil spills and rapid response to, emergency response decision making for and disposal of oil spill accidents are achieved, and the capacity and efficiency of prevention and control of oil spills are improved to provide scientific basis for emergency disposal of emergent oil spill accidents in the ocean [3].

3.2. Building of early warning capacities for oil spills

The building of early warning capacities for oil spills mainly consists of hydrodynamic models, oil spill models and environmentally sensitive area charts and can offer changes in oil spill trajectories, scopes of diffusion and physiochemical processes through numerical simulation based on the on-site information of oil spill accidents, disposal and personnel, equipment allocation and transfer plans for marine oil spill accidents, transportation, storage and disposal solutions etc. for recycled oil and oil-tainted waste to provide technical support and decision guarantee for quickly and efficiently handling marine oil spills and reducing pollution damage [4].

3.3. Building of command and organization coordination mechanism for oil spills

3.3.1. Organizational structure. Level 3 oil spill emergency response organization structure for offshore petroleum production operations has been established in Chengdao oil field.

3.3.2. Communication mode

The present communication mode is mainly classified into two categories of VHF (covering the entire offshore area of Chengdao oil field) and SSB (covering the entire offshore area of Chengdao oil field). The communication network for emergency response personnel has been built to define modes of communication inside the oil field and between various platforms and connections with the responsible departments and related units.

Figure 2. Oil spill emergency response organization structure chart
3.4. Building of on-site oil spill disposal capacities

3.4.1. Division of labor for oil spill disposal site personnel. After oil spill accidents happen, on-site work should be directed by On-site Emergency Response Command in accordance with the instructions from the emergency response command center and approved emergency disposal guidance programs. On-site implementation teams are set up respectively for various production platforms and oil spill response vessels. The production management department and the environment protection office participate in oil spill site disposal and carry out work according to arrangement by the command.

3.4.2. Emergency response procedure. Emergency response procedures for oil spill accidents in the oil field formulated in Chengdao oil field define disposal measures and centralized responsible units and play a guiding role in the emergency disposal of oil spill accidents.

3.4.3. Measures on control and elimination of oil spills. Strength of oil spill emergency response force, whether oil spill elimination facilities can be quickly and efficiently invoked and weather and sea condition factors have an influence on the results of treatment on marine oil spills. Besides, characteristics of oil pollution are also an important factor that affects marine recycling and treatment results [5]. Therefore, when oil spills are found in the sea, it is necessary to analyze and judge the properties and composition of spilled oil and then rapidly and appropriately transfer proper emergency response force to attend emergency response activities according to related technical requirements, operating procedures and emergency response plans.

![Figure 3. Oil spill emergency response procedure for Chengdao oil field](image)
Based on the difference of characteristics, diesel and motor oils are mainly disposed through natural volatilization and degradation accelerated by manual intervention and crude oils are mainly disposed through mechanical recycling combined with chemical methods [6]. As the oil field is close to the land, the base on land must be provided with coastline cleanup equipment and accomplish preparation work for coastline cleanup within half an hour after receipt of early warnings. In case of arrival of spilled oil on the coastline, cleanup work should be conducted immediately to reduce the extent of impact and lower loss.

3.4.4. Supervision of oil spills in the accident site. Once oil spill accidents happen, it is necessary to arrange on-site oil spill monitoring and supervision work while organizing emergency disposal of oil spills, which advisable is synchronized with assessment of damage of oil spill accidents to environment. Collaborations between various departments cover environmental water quality detection, oil spill drift path tracking and weather forecast and other works.

3.5. Emergency response and security coordination systems for oil spills
Building an emergency response and security coordination system for oil spills than combined the interior and exterior of Chengdao oil field provides possibility to request support from Yantai Maritime Safety Administration, PetroChina Marine Emergency Rescue Response Center and other units when major oil spill accidents happen or the emergency response force of the Shengli Petroleum Administrative Bureau and the equipment or personnel required for oil spills have trouble coping with oil spills.

3.6. Building of mechanism for assessing the damage of oil spills to environment
The building of mechanism for assessing the damage of oil spills to environment requires the unit where oil spill accidents happen to submit damage assessment reports within three months after the end of emergency response to oil spills, including the following contents: basic information of the oil field where accidents occur, causes of the accident, process of the accident, losses and consequences caused by the accident, as well as adopted measures on emergency response, acquired results, experiences and lessons, and prevention measures for similar accidents etc., and clearly define the modes and methods of compensation and repair for ecology and resources in oil spill accidents.

4. Conclusion
Enhancing marine oil spill risk management is an important means for preventing occurrence of marine oil spill accidents. Allocating resources for emergency response in a scientific and reasonable way and strengthening prevention and control capacities for oil spills is the key to improve efficiency in emergency response to marine oil spills and reduce pollution damage of oil spills. Currently effective monitoring and supervision and early warning system construction is absent in our county. Therefore, constantly reinforcing the building of oil spill monitoring and supervision capacities and early warning systems not only contributes improves the effectiveness of emergency response to oil spills and thus realizes business-based operation, but also can provide reliable and accurate basis for responsible departments in command and decision-making.

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