8-28-2016

The oil spill risk assessment and research on the oil pollution emergency plan in CNOOC(Huizhou) logistics base wharf

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The Oil Spill Risk Assessment and Research on the Oil Pollution Emergency Plan in CNOOC (Huizhou) Logistics Base Wharf

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A dissertation submitted to the World Maritime University in partial fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE
In
MARITIME AFFAIRS
(SHIPPING MANAGEMENT)

2016

DECLARATION

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

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

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ACKNOWLEDGEMENTS

I am sincerely grateful to World Maritime University for offering me this opportunity to study in Dalian, China. My sincere appreciation also goes to all the professors of WMU and DMU, who have tutored and supported me a lot during my study in Dalian.

I am thankful to my supervisor Prof. Jiang Xin, for guiding me through this work and providing me with invaluable advice and insights into the subject matter.

I also deeply appreciate Shanghai Salvage Bureau of Shenzhen Huawei Offshore Shipping Co., Ltd for offering me this opportunity to study, for their recommendation which is a chance and inspiration for the completion of my studies.

Last but not least, I want to thank my families who are always encouraging me by offering their full support. The success and achievement I made during my studies in Dalian would not have come true without their never-ending support.

Deep thanks also goes to my classmates.

ABSTRACT

Huizhou Dayawan petrochemical industrial park is located in eastern Dayawan bay development zone. CNOOC (Huizhou) Logistics Base Wharf is located in petrochemical industrial park. The CNOOC (Huizhou) Logistics Base Wharf is located in Dongma Port Area of Huizhou Port. This 292 meters long wharf is built with two berths for 5000-ton general cargo ships. The wharf resides at southeast of Daya Bay petrochemical area and east of Guohua Power Plant. The specific coordinates of the wharf are: 114°38'05.09"E, 22°45'02.50"N.

Therefore, CNOOC (Huizhou) Logistics Base Wharf of the oil spill emergency plan and the wharf emergency management conducting the thorough research are especially important.

According to the characteristics of the CNOOC (Huizhou) Logistics Base Wharf, it is very important to survey the natural environment, wharf and channel, combining CNOOC (Huizhou) Logistics Base Wharf of the oil pollution emergency plan and the wharf emergency management, analyzing the oil spill pollution source, oil spill impact factors and the risk of oil spill, Using "oil particle" model of wharf apron and channel on the numerical simulations of the oil spill, and referencing CNOOC (Huizhou) Logistics Base Wharf of existing oil pollution emergency plan and the wharf emergency management, to make a more perfect oil pollution emergency plan and emergency management.

Combined with the actual conditions of the CNOOC (Huizhou) Logistics Base Wharf, for onshore oil spill and the oil spill at sea, the corresponding prevention measures and emergency treatment of oil spill equipment and methods are put forward respectively.

After the analysis of CNOOC (Huizhou) Logistics Base Wharf of the oil pollution emergency plan, and the prevention of the CNOOC (Huizhou) Logistics Base Wharf against oil pollution emergency plan of the problems is summarized, suggestions for improvement are put forward.

KEY WORDS: oil pollution emergency plan, oil particle

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Chapter 1 Introduction

1.1 Research Background

1.1.1 Requirement of the Marine Environment Protection

Oil spill pollution is one of the most major oil pollutions in marine oil pollution, most of which showed strong randomness and suddenness. Sometimes, there were as many as hundreds of thousands of tons of oil spill, whose damage is very serious. A large amount of oil instantaneously was spilt into the marine environment, and the oil can be quickly spread into a large area causing the death of a large number of seabirds and fish, and it also made serious damages to marine resources. In addition, the spread of the oil spill and drift dynamics leads to damage of the beach, coast, tourist areas with beautiful natural scenery. If an explosion and fire take place at the same time, there will be the more disastrous consequences.

With a continuous development of marine economy, many countries around the world put forward higher requirements of the maritime transport ability and level of ocean energy development, in the process of port construction and resource focus, and the probability of pollution accident is also presents a rising trend. In recent years, marine pollution accidents happened both at home and abroad successively, such as the U.S. Gulf of Mexico oil spill accidents, Bohai bay Penglai 19-3 oil spill accident, "7.16" Dalian Marine pollution incident. The oil pollution's direct damage is not only harmful to the marine ecological environment, but also detrimental to the state and enterprise image. In response to sudden pollution accidents at sea, countries around the world have introduced relevant laws and regulations, and carried out related research, strengthening construction on Marine pollution emergency ability, as well as improving the level of disposal on emergency pollution accidents in an all-round way.

1.1.2 Requirement of the Policy of the Relevant Pollution Prevention

Early in September 2009, the state council promulgated the regulations on the prevention and control of vessel pollution to the marine environment management (namely state council order no. 561), as is stipulated in article 5: the coastal local people's government at or above the level of district-constituted municipalities shall, in accordance with the prevention and control of the ship and related activities approved by the state council to the Marine environment pollution emergency capability construction planning, and according to the actual situation in the region, to organize the formulation of corresponding prevention and control of Marine environmental pollution by ship and its related activities emergency capability construction planning.

In January 2011, the ministry of transport issued the law of the People's Republic of China on marine environmental pollution by ship emergency preparedness and emergency disposal regulations (namely transportation ministry made in no. 4, 2011), which was explicitly pointed out in article 5: the plan of coastal city operation activities related to the prevention and control of the ship and its pollution to the marine environment emergency ability construction shall, according to the local people's government at the provincial level operation activities related to the prevention and control of the ship and its pollution to the marine environment emergency capability construction planning and the local actual situation, the municipal people's government shall organize the formulation of coastal districts and carry out. All levels of coastal maritime management institutions shall actively assist and cooperate with relevant local people's government to complete the planning of emergency capability construction work.

At the beginning of 2013, Ministry of transport has carried out the two major works of the national major marine oil spill emergency plan and the national major marine oil spill emergency ability construction plan. At present, the compiling outline of the national major marine oil spill emergency ability construction plan has been through the review. In order to establish an event of oil spill emergency disposal system of Guangdong province, and improve the emergency mechanism, in April 2014, the general office of the Guangdong people's government issued the oil spill emergency response plans.

1.2 Purpose of Research

In recent years, marine oil pollution accidents were of frequent occurrence due to the increase of oil transportation, and marine oil pollution has brought disastrous consequences to marine environment, human health, marine life and social economic development. Oil spill accident has become a serious environmental and social problem.

In order to strengthen the environmental protection to promote Huizhou petrochemical logistics base port's sustainable development, enhance the overall ability of Huizhou petrochemical logistics base port waters pollution risk to cope with disposal, and improve Huizhou petrochemical logistics base port waters pollution risk comprehensive emergency management level, it is important to take effective control of marine environment risk accidents.

1.3 Introduction of the Treatment Method of Oil Pollution

In the event of oil spill accident, the current processing methods mainly include: mechanical recycling treatment, chemical treatment, biological treatment and combustion method.

1.3.1 Mechanical Recycling Treatment

Mechanical method is to use machinery to eliminate the surface and coastal zone, because the processing method of oil spill is usually not suitable for emulsified oil physical processing. Instruments of mechanical recovery method used are mainly with booms, skimmers, spilled oil absorption material, and so on.

1.3.2 Chemical Treatment

When the oil film is thinner, it is difficult to recycle oil by mechanical method, or may be in a fire emergency cases, but it can be used chemical treatment. One of the most widely used is condensed oil and dispersants.

1.3.3 Biological Treatment

It is difficult to deal with oil spill with physical method to remove the oil film on the surface of the water and oil soluble in water. Furthermore, it is likely to cause secondary pollution with chemical method throwing synthetic chemicals to the sea. Marine microorganisms are in a large quantity and various in the sea, with the characteristics of wide distribution and strong adaptability. Compared with physical and chemical methods, biological treatment have incomparable advantages using bacteria to remove things dissolved in oil film on the surface of the sea water and sea petroleum hydrocarbons. Since the 1970s, biological treatment has been started to be adopted abroad for the research of bioremediation of oil spill at sea, and now it has entered the stage of practical research. It has created the bioremediation of marine pollution, and the United States has been using this technique successfully to eliminate the Exxon Valdez caused by large areas of oil spill pollution.

1.3.4 Combustion Method

Under certain conditions of oil spill, it is an effective method to use marine incineration treatment technology in a relatively short period of time to get rid of a large number of oil spills. From the early 1970s, it began to develop the technology, but it is rarely applied in the actual oil spill accidents. However, it is still considered a promising and valuable, because it can deal with large amounts of oil spill. If the operation method is right, in some cases, the technology will be superior to traditional compound control and recovery technology. Combustion method is relatively simple, and it doesn't have to consider the storage, transportation, or the recovery of oil and oil/water mixture.

If extensive oil spill pollution was caused by ship accidents, most of the oil spill can be removed by the combustion process. Combustion should be used in a variety of accelerant to make a lot of oil spill burn out in a short time, without complex device or low processing cost. Considering the products of combustion influencing on the growth and reproduction of marine organisms, and damage near to the ship and shore facilities, furthermore, when burned, smoke will pollute the atmosphere, therefore, combustion can only be used in the high seas, which is quite far away from the coast.

In the four kinds of processing technology of oil spill, mechanical recycling is the most basic and the most common one. Its flexibility is strong, and can adapt to the medium and the following sea state assignment. Oil spill recovery rate is high, and there is no secondary pollution, It is the first selection of oil spill accident treatment method. Chemical treatment method can be used in the rough sea condition, because the cost is low. Compared with combustion method, it has a high value for development, applicable to the high seas far away. Biodegradation technology is used for environmental sensitive shoreline, and is commonly used in the second step of spilled oil removal technology, In some specific conditions, it is used to enhance the natural environment's final residual pollutants degradation ability.

Table 1.1: Comparison on the advantages and disadvantages of clearing the oil spill

Technology	Advantages	Disadvantages
Mechanical recycling treatment	Effective in winter Effective in smooth water area Suitable for the ice surface Effective on the surface of oil spill	No effect on the surface of high-density crushed ice No effect in rough sea No effect under heavy fogs on the sea surface
Chemical treatment	Effective thin oil film Work quickly Suitable for rough sea	Easy to produce secondary pollution
Combustion method	Effective the first oil spill Fire-resistant oil boom and at least 2-3 mm of the oil film Suitable on the surface of high-density crushed ice	Produce a polluted air effect on shore residents Residue after burning No effect on weathering oil No effect on emulsified oil
Biological treatment	Effective for some crude oil under moderate temperatures	No effect under low temperatures No effect on weathering oil and emulsified oil

		Likely affect marine life

1.3.5 Best Choice of Handling of Oil Spill in the CNOOC (Huizhou) Logistics Base Wharf

Comparing the above several methods of oil spill treatment method, and combined with the practical situation of the CNOOC (Huizhou) Logistics Base Wharf, mechanical method is usually selected. Firstly, there are so many islands around the CNOOC (Huizhou) Logistics Base Wharf that the surface of sea is calm, and it is advantageous to the mechanical method recovery of the oil spill; due to the CNOOC (Huizhou) Logistics Base Wharf is in 114°38'05.09"E, 22°45'02.50"N, it is located in a subtropical area and has a typical subtropical maritime climate, with the water temperature of 17.6 ℃–18 ℃ in spring and 26.4 ℃–29.4 ℃ in summer, and the lowest water temperature is estimated to be around 10 ℃ in water. The natural environment is also advantageous to the mechanical method recovery of the oil spill. Secondly, the mechanical method recovery of oil spill is not easy to produce second pollution, and there are living areas, tourist areas and shellfish breeding near the CNOOC (Huizhou) Logistics Base Wharf. Finally, the mechanical method recovery of oil spill requires a lot of manpower and recovery tools; however, the wharf is the easiest way to provide.

1.4 Introduce the Application of Emergency System in Abroad

The use of emergency theory abroad is many years earlier than in China. In the late 1970s and early 1980s, there were relatively perfect emergency management agency, operating system and regulations abroad.

The United States has established a national, regional and local level 3 emergency organization and every level organization has its own emergency plan. National emergency group is a national plan and policy coordination entity, not directly for accident emergency response, but just used before the accident policy guidance and assistance in the process of accident treatment. Its members were from the EPA, the coastguards and other federal departments responsible for environmental management.

For marine oil pollution emergency organization system, Britain has two levels of accident emergency agencies. In transportation subordinates, the government is equipped with marine pollution management committee, and the competent maritime emergency operations director is in charge of marine pollution management committee, responsible for dealing with maritime pollution accidents and coordinating coastal beach clean-up efforts among the local authorities. The government has built national assault force, spraying oil dispersant with special planes and ships and oil spill recovery of machinery and equipment, local government is responsible for the cleanup of marine environment pollution of oil spill accidents. The local authorities are under the government's department of the environment, coordination, and the local government is responsible for the local beach cleanup. The main expenses shall be borne by the local government. The local government has the professional beach clean team, the staff accept beach cleanup job training and a large-scale drill twice a year. In 1979, on the basis of the improvement of emergency mechanism, the sea area of responsibility of the pollution control board was first adjusted, and then a Marine commander and a land operator were adjusted into the bureau which has two sub-branch organizations. Moreover, the government has expanded pollution emergency power and strengthened the coordination work in the oil spill cleanup job. Marine pollution control bureau and oil industry formed a formal work group to set up some local agencies including the central government, oil companies and other economic entities. Then oil pollution can be used to clean up the list of manpower and material resources. All of these economic entities jointly deal with the pollution accident.

France's emergency mechanism is divided into two sets of systems of sea and terrain, and respectively sets up two level emergency organizations. In central, there are competent secretaries of state under the ministry of maritime commission and interior minister under the director of Civil Security Council, who are responsible for emergency plan approval and control work, and the national emergency drill respectively. At the local level, the coastal defense command (military) is responsible for planning and guiding emergency control operation, and the coastal defense command collaboration with local authorities and maritime enterprises enact emergency plan and organize personnel training exercises. France's pollution clean-up relies mainly on the company and folk which contribute to manpower and material resources, all of which generally take temporary renting or requisition. Furthermore, the government is equipped with a powerful tug and a team of the crew in each area, and civil and military institutions are equipped with several operations teams which are responsible for the processing work of maritime accidents.

In Germany, the task of removing oil pollution is the responsibility of the government and coastal states including Breman, Hamburg, Lower Saxony and Schleswig-Holstein. The organization structure is divided into several parts: the first one is the committee, composed of experts of oil pollution accidents; the second is the removal team responsible for the clean-up of the oil; the third is the alarming mechanism about oil pollution accidents. The agency is located in the national center for alarm and works for 24 hours to report to various international and domestic stations for oil pollution accident; the fourth is the offshore special group, whose task is authorized examining and approval the plan, which is put forward by the committee composed of experts of oil pollution accidents. In the case of oil pollution accident, the offshore special group will support the clean-up team to clean; the fifth is the consulting institute which provides knowledge to competent authorities about removing oil pollution, and puts forward research plans and suggestions.

Through a comparison of the above countries emergency organization forms, we can find some common points: firstly, the countries have complete legal systems, and give priority to with national emergency plans; secondly, the relationship between organizations and convenient institutions is clear at all levels; thirdly, there are the most basic standing bodies in these countries of the emergency organization structure, such as the 24-hour on-duty alarm mechanism of oil spill and the highest decision-making power of oil spill emergency command center.

Chapter 2 Survey of CNOOC (Huizhou) Logistics Base Wharf's Status Quo

2.1 Wharf Overview

The CNOOC (Huizhou) Logistics Base Wharf is located in Dongma Port Area of Huizhou Port. This 292 m long wharf is built with two berths for 5000-ton general cargo ships. The wharf resides in the southeast of Daya Bay petrochemical area and east of Guohua Power Plant. The specific coordinates of the wharf are: 114°38'05.09''E, 22°45'02.50''N. The berth area in front of wharf is 37-meter wide, and the bottom elevation of the berth area is -8.6 m. A turning basin with a diameter of 248 meters is positioned straight ahead of the wharf. Its bottom elevation is -8.5 m, just the same as the navigation channel. The navigation channel has an effective width of 65 m, with a bottom elevation of -8.5 m, and a total length of about 3.8 km.

2.2 Natural and hydrological environment

2.2.1 Geographical Location

The CNOOC (Huizhou) Logistics Base Wharf is situated on Daya Bay which is to the north of South China Sea, spanning from 114°38'E to 114°50'E and 22°30'N to 22°50'N. Daya Bay covers an area of 600 km^2 and incorporates more than 50 islands. Its middle part is composed of a string of small islands running from south to north, which divides Daya Bay into two parts. The eastern outfall of Daya Bay is 9.6 km wide and 19–20 m deep, while the western outfall is 5.4 km wide and 19 m deep.

2.2.2 Climate

Daya Bay is located in a subtropical area and has a typical subtropical maritime climate, which is characterized by high temperature, humidity, and rainfall.

2.2.3 Wind regime

At the wharf, the prevailing wind direction is NNE from September in the previous year to April of the current year, and SE-SSE from May through August. The annual calm wind frequency is 25% all the year around, while the monthly calm wind frequency ranges from 20% to 29%. Most prevailing winds during the year are those from NNE, and the secondary prevailing winds are from SE.

2.2.4 Tropical Cyclone

Tropical cyclones attack Daya Bay 9.3 times on average each year, mainly from June to October, and the attack is particularly serious between July and September.

2.2.5 Rainfall

About 80% of rainfalls occur between May and September in Daya Bay, and the highest rainfall comes in months from June to August. Dense fog occurs for an average of 5.1 days per year, mostly in winter and spring.

2.2.6 Tide

Tide: irregular semi-diurnal tide. Average tidal range: 1.03 m. Maximum tidal range: 2.68 m. Mean sea level: 1.17 m (The theoretically lowest tide level in local area is used as the base level). Design high water level: 2.27 m. Design low water level: 0.17 m. Extreme high water level: 3.63 m. Extreme low water level: -0.40 m. Riding high tide level: 1.08 m (assurance rate of high tide level: 90%; last hours of high tide level: 2 hours).

2.2.7 Current

The maximum flow velocity in Huizhou port area is 16 cm/s during flood and 24 cm/s during ebb. The average flow velocity is 7 cm/s during flood and 8 cm/s during ebb. The current direction is 9 degrees during flood and 130 degrees during ebb. Therefore, Daya Bay is a weak tidal bay.

2.2.8 Water Temperature and Salinity

The bottom water temperature in Daya Bay is 17.6 ℃–18 ℃ in spring and 26.4 ℃–29.4 ℃ in summer. The lowest water temperature is estimated to be around 10 ℃ in water. This sea area is barely affected by surface runoff, but mainly controlled by external water masses. The salinity of water body is about 30‰ per year.

2.2.9 Wave

The generation, subsidence, and spread of waves in Daya Bay are subject to typhoon and cold air activities, as well as topography. Waves are rapidly weakened due to the blocking of many islands and capes when flowing into Daya Bay through the mouth of the bay. The prevailing wave direction and the wave direction under strong wind condition are both E-SE. The wave heights inside the bay are usually below 3.0 m. Waves less than 0.5 m high (H1/10) accounts for 46.7%. In the event of maximum wave height, most waves come from ESE and SE directions at a frequency of 62.7%. The monthly average wave heights are of little variation, but the maximum wave heights vary dramatically. Affected by typhoons from June to November, wave heights fluctuate greatly from 2.9 m to 4.6 m. The maximum wave height is merely 2.2 m in May and 4.6 m in September.

2.3 CNOOC (Huizhou) Logistics Base Wharf

The CNOOC (Huizhou) Logistics Base Wharf in Phase I (already open) is built along the coastline for 292 meters long with two 5000-ton general cargo ship berths. Upon completion of Phase II (in progress), the coastline will reach 795 meters long with one 3000-ton general cargo ship berth and one 5000-ton diesel-powered vessel berth. After the wharf construction is completed, a maximum of five offshore supply vessel (OSV) berths can be deployed in consideration of oil loading and unloading, or a maximum of nine OSV berths for non-oil operations. At present, the approach channel finished in Phase I is -8.5 m deep, 65 m wide, and 3800 m long. Depth and diameter of the turning basin are -8.5 m and 248 m respectively. Waters in front of wharf are -8.6 m deep.

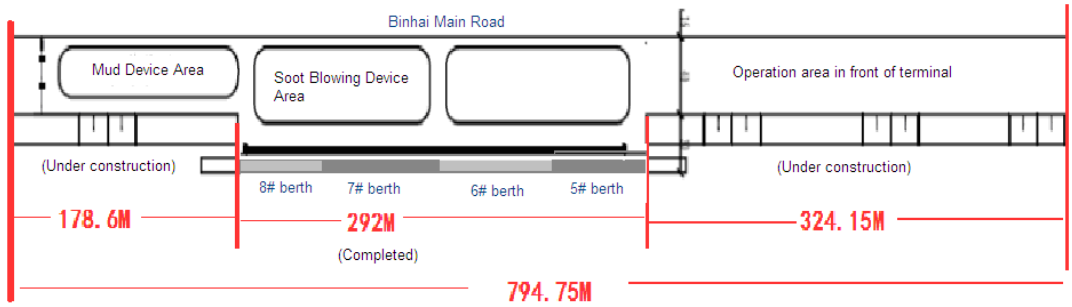

Figure 2.1: Plan View of the CNOOC (Huizhou) Logistics Base Wharf

2.4 Navigation Environment

2.4.1 Channel

The channel of the CNOOC (Huizhou) Logistics Base Wharf is designed to allow navigation of 5,000 DWT general cargo ships. Considering that the cumulative frequency of high tide level is 90% and the cumulative time of high tide level is 2 hours, therefore, the tide-bound water level is 1.08 m. The design bottom elevation of 5,000 DWT general cargo ship channel is -8.5 m, which can satisfy the needs of tide-bound access of 5000-ton general cargo ships and of 24-hour access of OSVs.

In order to meet the requirement of channel depth and ensure the safety of CSPC submarine sewer pipe running SE-NW, the approach channel is basically consistent with the general plan of Huizhou Port and the axial line of the approach channel is parallel with the submarine sewer pipe. Ships which intend to berth in this wharf shall first enter Donglian waterway in Huizhou Port, and then access the channel of this wharf when approaching H1 and H2 buoys. The branch access channel of this wharf is 3.8 km long with 65 m bottom width and -8.5 m design bottom elevation. The azimuth of the central line of the access channel is 133°15′36″–313°15′36″. A total of 10 light buoys are deployed at the wharf. They are equipped with LED beacon lights with a nominal range of 3 nautical miles. The specific coordinates and the signaling features of these buoys are listed below:

Table 2.1: The specific coordinates and signaling features of these buoys of Donglian waterway

NO.	Buoy No.	Coordinates		Signaling Feature
1	H1	22°43′34.10″N	114°39′49.70″E	Quick flashing green
2	H2	22°43′31.60″N	114°39′47.40″E	Quick flashing red
3	H3	22°44′02.00″N	114°39′18.20″E	Flashing green for 4 seconds
4	H4	22°43′59.60″N	114°39′15.80″E	Flashing red for 4 seconds
5	H5	22°44′29.90″N	114°38′46.30″E	Flashing (2) green for 6 seconds
6	H6	22°44′27.50″N	114°38′43.90″E	Flashing (2) red for 6 seconds

7	H7	22°44′59.30″N	114°38′12.30″E	Flashing (3) green for 10 seconds
8	H8	22°44′56.80″N	114°38′10.00″E	Flashing (3) red for 10 seconds
9	H9	22°45′05.30″N	114°38′10.30″E	Flashing green for 4 seconds
10	H10	22°45′01.80″N	114°37′58.30″E	Flashing red for 4 seconds

Two leading marks (namely front and rear leading marks) are deployed at the wharf. They stay solid red, with a horizontal divergence of 3 ° and a nominal range of not less than 7 nautical miles. The specific coordinates of these leading marks are listed below:

Table 2.2: The specific coordinates of these leading marks

1	Front leading mark	22°45′10.70″N	114°37′56.70″E
2	Rear leading mark	22°45′26.10″N	114°37′39.40″E

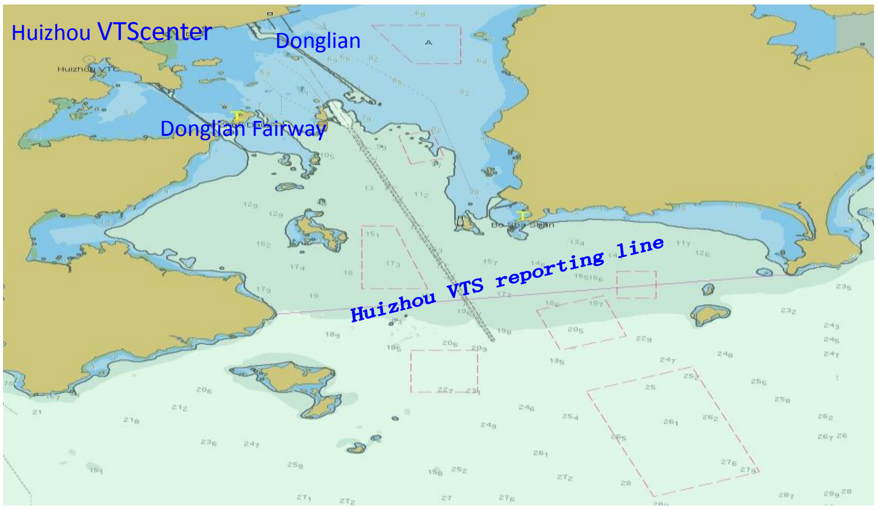

Figure 2.2: Map of Huizhou VTS Area

2.4.2 The Status Quo of Anchorage

With the expansion of Huizhou Port, existing anchorage seems crowded for different types and quantities of incoming ships. Huizhou Maritime Bureau conducted a re-planning of the Huizhou Port anchorage in 2004. The adjusted anchorage locations and areas are listed in the following table:

Table 2.3: The adjusted anchorage locations and areas

Anchorage name	Anchorage area	Description
Anchorage No.1	The water area with position 22°40′30″N/114°33′00″E as center and 0.4 nautical miles in radius.	The Chinese-flagged cargo ship (Maximum draft less than 5 meters).
Anchorage No.2	The water area with position 22°39′12″N/114°36′54″E as center and 0.4 nautical miles in radius.	The cargo ship (Deadweight less than 5000 MT).
Anchorage No.4	The water area with position 22°36′00″N/114°37′30″E as the center and 0.5 nautical miles in radius.	The tanker (Deadweight less than 20000 MT).
Anchorage No.5	The water area within joint line connecting following points: A、22°44′31″N/114°40′18″E; B、22°44′31″N/114°43′00″E; C、22°42′43″N/114°43′00″E; D、22°42′43″N/114°41′33″E	The general cargo ship (Deadweight less than 5000 MT).
Anchorage No.6	The water area within joint line connecting following points: A、22°39′16″N/114°41′08″E; B、22°39′32″N/114°42′07″E; C、22°38′13″N/114°42′29″E; D、22°37′57″N/114°41′30″E	The tanker (Deadweight less than 30000 MT).
Anchorage No.7	The water area within joint line connecting following points: A、22°35′00″N/114°40′00″E; B、22°35′00″N/114°41′00″E; C、22°32′00″N/114°42′00″E;	The cargo ship (Deadweight between 30000 MT and 80000 MT)

	D、22°32′00″N/114°40′00″E	
Anchorage No.8	The water area within joint line connecting following points: A、22°29′05″N/114°41′30″E; B、22°29′05″N/114°43′30″E; C、22°27′06″N/114°43′30″E; D、22°27′06″N/114°41′30″E	The cargo ship (Deadweight between 30000 MT and 80000 MT)
Anchorage No.9	The water area within joint line connecting following points： A、22°31′00″N /114°45′18″E B、22°31′40″N /114°47′18″E C、22°29′46″N /114°48′00″E D、22°29′06″N /114°46′00″E	The bulk carrier (Deadweight between 30000MT and 150000 MT)
Anchorage No.10	The water area within joint line connecting following points： A、22°32′51″N /114°47′44″E B、22°32′51″N /114°48′54″E C、22°31′34″N /114°48′54″E D、22°31′34″N /114°47′44″E	The cargo ship (Deadweight between 30000 MT and 100000 MT)
Anchorage No.11	The water area within joint line connecting following points： A、22°27′08″N /114°46′48″E B、22°28′18″N /114°50′00″E C、22°23′18″N /114°52′02″E D、22°22′08″N /114°48′50″E	The tanker (Deadweight between 50000MT and 300000 MT)
Anchorage No.12	The water area with position 22°34′30″N/114°51′42″Eas center and 0.4 nautical miles in radius.	The cargo ship (Deadweight less than 10000 MT).

The anchorages of this wharf are intended for piloting and berthing of 5000-ton general cargo ships. In accordance with planning, OSVs can cast anchor in No.11 anchorage which resides southeast of the starting point of the approach channel of the wharf. This approach channel can meet berthing requirements in terms of water depth and scope. The arrangement from the VTS Center of Huizhou Maritime Bureau shall prevail if a special circumstance arises.

2.5 Surrounding and Sensitive Areas

The east of the CNOOC (Huizhou) Logistics Base Wharf is Xiayong town, and the west of the CNOOC (Huizhou) Logistics Base Wharf is Aotou town, and there are 40.000 residents living in these two towns. Near the CNOOC (Huizhou) Logistics Base Wharf, there are two CSPC petrochemical projects which have been completed, and three CNOOC oil refining projects. The CNOOC (Huizhou) Logistics Base Wharf peripheral enterprises and facilities are shown in the table below:

Table 2.4: Peripheral enterprises and facilities

Serial number	Name of the place of environmental risk sensitive	Orientation	Distance(km)
1	Xiayong town	NE	2.0
2	CNOOC refinery project living area	E	1.0
3	Guohua power plant	W	0.2
4	Xin double(Huizhou) CO. LTD	E	0.2
5	Hainengfa petrochemical factory	E	0.2
6	CNOOC international freight forwarder CO. LTD(Huizhou)	N	0.3

In addition, near the CNOOC (Huizhou) Logistics Base Wharf, there are tourist areas, shellfish breeding, reserves Guohua power plant water intake and so on. Sensitive situations are shown in the table as follows:

Table 2.5: The Main Environmental Sensitive Areas

Serial number	Name of the Sensitive area	Position	Distance(km)	The main object of protection	In functional areas
1	The south oven shellfish breeding area	E	4.5	Shellfish breeding area	The third type of seawater

2	Geese continent shellfish breeding areas and islands coral communities	S	3.2	Shellfish breeding area and coral reef	The second type of seawater
3	Trail bay shellfish reserves	E	7.2	Shellfish reserve	The second type of seawater
4	The middle of the buffer	S	7.5		The second type of seawater
5	The central core	S	8.5	Fish Zhou Miao, fish and shellfish precious care proliferation	The first type of seawater
6	Xiayong tourist area	W	1.8	Travel and swimming	The second type of seawater
7	Xunliao tourist area	SE	14.4	Travel and swimming	The second type of seawater
8	Savory Angle tourist area	E	11.2	tourist	The second type of seawater
9	Guohua water intake	W	2.41	The cooling water intake	The third type of seawater

Chapter 3 Understand the Related Principle of the Oil Spill

3.1 The Principle of the Oil Spill Model

The component of the oil film is constant in the processes of transport such as diffusion and drift, and the line of oil will change in the process of weathering. The process of weathering includes evaporation, dissolution, biodegradation, emulsification, oxidation and so on. In the process of the oil spill transport and weathering, between water, oil film and the atmosphere's constant change of heat transfer, and some properties of the oil film such as viscosity, the surface tension also changes due to the change of the oil film components. Through the oil particle model of MIKE21SA, it is useful for oil spill accident's forecast and analysis, not only because the model has good simulation results for physical and chemical processing, but also because the model has been widely used in the world. At the same time, the model has a high stability and high efficiency due to its Lagrange system. It can be explained in the oil particle model in this way: Each oil particle is defined as containing a certain amount of oil, and a large number of oil particles are called the oil film. Firstly, the oil particles were calculated for each position, composition and moisture content changes, and then it can calculate the number of oil particles on the grid and the content of each component, and it can simulate the component change of the oil film and the concentration change of time and space. Finally, it can calculate the changes of the oil film of the chemical and physical according to the oil film composition and temperature changes.

3.2 The Transport Process of the Oil Particles

It is very complex in process of conveying and transferring, including extension, drift and diffusion, and so on. These processes alter the position of the oil particles.

However, their specific composition does not change with the process.

3.2.1 Extension Movement

In the extension movement, the use of the simulation model is revised Fay gravity - viscous force formula, which is specified as follows:

$$\left(\frac{dA_{oil}}{d_t}\right) = K_a \cdot A_{oil}^{1/3} \cdot \left(\frac{V_{oil}}{A_{oil}}\right)^{4/3}$$

$$A_{oil} = \pi R_{oil}^2$$

$$V_{oil} = \pi R_{oil}^2 h_s$$

Type in the letters on behalf of:

h_s —— The initial oil film thickness(cm), h_s=10cm;

R_{oil} —— The oil film diameter;

K_a —— Coefficient

t —— time;

A_{oil} —— the oil diffusion area;

V_{oil} —— The volume of the oil film.

3.2.2 Drift Movement

In the process of oil particle drift, the dominant factor is the water and wind. Its total drift velocity can be calculated by the weight of the following formula:

$$U_{tot} = c_w(z).U_w + U_s$$

Type in the letters on behalf of:

U_{tot} —— Total oil particle drift velocity;

U_w —— The wind speed (In the ten meters above the surface of the water);

U_s —— The surface flow velocity;

c_w —— The wind drift velocity.

With the help of the meteorological department, we can easily obtain the relevant data of wind field and flow field data can be in a two-dimensional hydrodynamic model of calculation results. But it is needed to note is that, from the two-dimensional hydrodynamic model, in general, the calculated results are the average of the vertical direction. Therefore, we must base on the results of the distribution of flow velocity in the vertical direction. We can assume that it can conform to the logarithmic relationship between them:

$$V(z) = \frac{U_f}{K} \cdot ln\left(\frac{h-z}{K_n/_{30}}\right)$$

$$U_f = \left(\frac{V_{mean} \cdot K}{ln\left(\frac{h}{K_n/30}-1\right)}\right)$$

$$z = h - \frac{K_n}{30}$$

Type in the letters on behalf of:

$V(z)$ —— The flow velocity (m/s);

U_f —— The friction resistance velocity (m/s);

k —— Von Karmans constant, k =0.42;

K_n —— Nikuradse resistance coefficient;

z —— The water depth (m);

V_{mean} —— The mean velocity (m/s).

3.2.3 Turbulent Diffusion

According to assumptions in the spread of the level, the isotropic is shown. Therefore, within a unit of time, in the direction of a all possible diffusion distance, Sa can be expressed as follows:

$$S_a = [R]_{-1}^{1} \cdot \sqrt{6 \cdot D_a \cdot \Delta t_p}$$

Type in the letters on behalf of:

S_a —— The possible spread distance within one time step on the direction of a（m）;

$[R]_{-1}^{1}$ —— The randomly generated count from -1 to 1;

D_a —— The diffusion coefficient in a direction.

3.3 The Weathering Process of Oil Particles

In the weathering process of oil particles, it generally includes evaporation, dissolution and several processes forming emulsion. In the process above, the component of oil particles will change, but in the horizontal direction, the location of the oil particles has not changed.

$$N_i^e = K_{ei} \cdot P_i^{SAT} / RT \cdot \frac{M_i}{\rho_i} \cdot X \cdot [m^3/m^2\ s]$$

$$K_{ei} = K \cdot A_{oil}^{0.045} \cdot Sc_i^{-2/3} \cdot U_w^{0.78}$$

Type in the letters on behalf of:

N_i^e —— Evaporation Rate;

K_{ei} —— Material transport coefficient;

P_i^{SAT} —— Vapor Pressure;

R —— Gas constant;

T —— Temperature;

M_i —— Molecular Weight;

ρ_i —— Partial density of line of oil;

i —— Some kind of line of oil;

K —— evaporation coefficient;

S_{C_i} —— The components of the i steam Schmidts number.

3.3.1 Emulsification

3.3.1.1 The formation of oil-in-water emulsion process

In the process of oil to the water movement, it roughly includes dissolution, diffusion and precipitation. At the beginning of a couple of weeks, diffusion is one of the main processes. Diffusion is purely a physical mechanical process. Under the action of water flow turbulent energy, the oil film is torn into oil droplets, and then the oil is parceled by water, this is the so-called emulsion. These emulsified materials become very stable under the action of surfactant, which prevents the oil droplets from dropping into the oil film again. Under severe weather conditions, the waves seem to be the main force of diffusion, but in calm weathers, it is a major force of diffusion into the spread of the oil film compression movement. From the whole process of diffusion, the expected loss amount can be calculated as follows:

$$D = D_a \cdot D_b$$

$$D_a = \frac{0.11(1+U_w)^2}{3600}$$

$$D_b = \frac{1}{1+50\mu_{oil} \cdot h_s \cdot \gamma_{ow}}$$

Type in the letters on behalf of:

D —— From the oil film diffusion to the oil from water loss;

D_a —— Component of oil into the water;

D_b —— After the oil into the water without return;

μ_{oil} —— Oil viscosity;

γ_{ow} —— Oil-water interfacial tension;

The rate of oil droplets returns oil film shows as follow:

$$\frac{d_{V_{oil}}}{d_t} = D_a \cdot (1 - D_b)$$

3.3.1.2 The formation of empties the other compound process

Moisture content in oil of change can be represented by the balance equation under the type:

$$\frac{d_{y_w}}{d_t} = R_1 - R_2$$

$$R_1 = K_1 \cdot \frac{(1+U_W)^2}{\mu_{oil}} \cdot (y_w^{max} - y_w)$$

$$R_2 = K_2 \cdot \frac{1}{A_S \cdot W_{ax} \cdot \mu_{oil}} \cdot y_w$$

Type in the letters on behalf of:

y_w —— The actual moisture content of oil;

R_1 —— The water absorption rate;

R_2 —— The release rate of the water;

y_w^{max} —— The largest oil moisture content;

A_S —— The asphalt content in oil(Weight ratio);

W_{ax} —— The wax content in the oil(Weight ratio);

K_1 —— The absorption coefficient;

K_2 —— The release coefficient;

3.3.2 Dissolution

The oil dissolving rate is shown as:

$$\frac{d_{V_{dsi}}}{d_t} = K_{S_i} \cdot C_i^{sat} \cdot X_{mol_i} \cdot \frac{M_i}{\rho_i} \cdot A_{oil}$$

$$K_{si} = 2.36 \times 10^{-6} e_i$$

Type in the letters on behalf of:

C_i^{sat} —— The solubility of the line of oil about i;

X_{mol_i} —— The mole fraction of the line of oil about i;

M_i —— The mole weight of the line of oil about i;

K_{si} —— The mass transfer coefficient of dissolution;

e_i —— e =1.4, hydrocarbon alkyl; e =2.2, aromatic hydrocarbon; e =1.8, the refined oil;

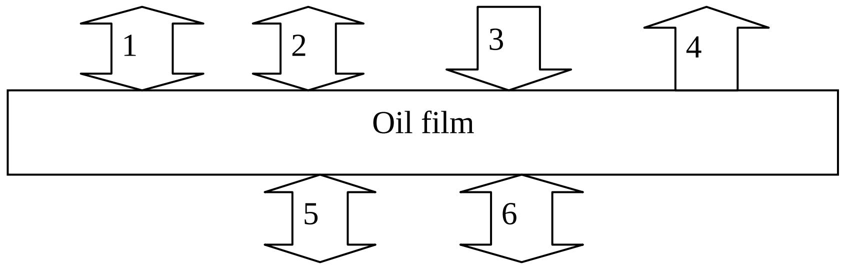

Figure 3.1: The thermal equilibrium diagram of the oil film

1: The heat transfer process between the atmosphere and the oil film

2: The thermal radiation process between the atmosphere and the oil film

3: Solar radiation

4: Evaporative heat loss

5: The heat transfer between the oil film and the water body

6: The heat radiation emitted and accepted between the oil film and water

3.3.3 The heat transfer process

The temperature is the main factor affecting the vapor pressure and viscosity. Through observation, we found that under normal circumstances, the temperature of the oil film is higher in comparison with the surrounding air.

3.3.3.1 The heat transfer between the oil film and the atmosphere

The heat transfer between the oil film and the atmosphere can be expressed as follows:

$$H_T^{oil-air} = A_{oil} \cdot K_H^{oil-air} \cdot (T_{air} - T_{oil})$$

$$K_H^{oil-air} = K_m \cdot \rho_a \cdot C_{pa} \cdot \left(\frac{S_c}{P_r}\right)_{air}^{0.67}$$

$$P_r = \frac{C_{pa} \cdot \rho_a}{0.0241(0.18055 + 0.003T_{air})}$$

$$K_H^{oil-air} = 5.7 + 3.8U_W$$

Type in the letters on behalf of:

T_{oil} —— The temperature of the oil film;

T_{air} —— The temperature of the atmosphere;

ρ_a —— The density of the atmosphere;

C_{pa} —— The heat capacity of the atmosphere;

P_r —— The number Prandt of the atmosphere.

3.3.3.2 Solar Radiation

It is affected by many factors of the oil film receiving solar radiation, such as the location of the oil spill and the weather conditions and so on. We assume that the adjustment of the change of radiation intensity of the day satisfy a sine relationship:

$$H(t) = \begin{cases} K_i \cdot H_0^{max} \cdot sin\left(\pi \frac{t-t^{sunrise}}{t^{sunset} - t^{sunrise}}\right), t^{sunrise} < 1 < t^{sunset} \\ 0, otherwise \end{cases}$$

$$t^{sunset} = t^{sunrise} + T_d$$

$$T_d = \alpha \cdot cos(tan\, \emptyset \cdot tan\, \xi)$$

$$\varsigma \cong 23.45\, sin\left(360 \frac{284}{365}\right)$$

$$H_0^{max} = \frac{12K_t}{t^{sunset} - t^{sunrise}} \cdot I_{sc} \cdot \left(1 + 0.033\, cos\left(\frac{360n}{365}\right)\right) \cdot (cos(\emptyset) \cdot cos(\varsigma) \cdot sin(w_\varsigma) + w_\varsigma \cdot sin(\emptyset) \cdot sin(\varsigma))$$

$$Q = (1 - \alpha) \cdot H(t)$$

Type in the letters on behalf of:

$t^{sunrise}$ —— The sunrise time(after the midnight second number);

t^{sunset} —— The sunset time(after the might second number);

T_d —— The length of day;

φ —— Latitude;

ς —— The sun angle (at noon the angle of the sun with the equatorial plane);

H_0^{max} —— At noon interstellar radiation;

I_{sc} —— Solar constant;

n —— The number of days in one year;

w_{ς} —— The hour angle of the sunrise. At twelve o 'clock, it is zero, it is equal to 15 per hour (it is right in the morning);

Q —— The input of net heat;

K_i —— Coefficient, in sunny days, K1=0.75, it is inversely proportional to the thickness of the clouds. Most of the sun radiation reaching the ground has been reflected;

α —— Diffusion coefficient.

3.3.3.3 The loss heat of evaporation

The loss heat of the oil film is caused by evaporation:

$$H^{vapor} = \sum_i N_i \cdot \Delta H_{vi} \cdot [W/m^2]$$

$$\frac{dT_{oil}}{d_t} = \frac{1}{\varsigma \cdot C_p \cdot \hbar} \cdot [(1-\alpha)H + l_{air} \cdot T_{air}^4 + l_{water} \cdot T_{waer}^4 - 2l_{oil} \cdot T_{oil}^4] + \hbar_{ow} \cdot (T_{water} - T_{oil}) + \hbar_{oa} \cdot (T_{water} - T_{oil}) + \hbar_{oa} \cdot (T_{air} - T_{oil}) - \sum N_i \cdot \Delta H_{vi} + \left(\frac{dV_{water}}{d_t} \varsigma_w \cdot C_{pw} + \frac{dV_{oil}}{d_t} \cdot \varsigma_{oil} \cdot C_{poil}\right) \cdot (T_{water} - T_{oil}) \cdot A_{oil}$$

3.3.3.4 The heat transfer between the oil film and the water body

It can be expressed as the heat transfer between the oil film and the atmosphere:

$$H_H^{oil} = A_{oil} \cdot K_H^{oil-air} \cdot (T_{water} - T_{oil})$$

$$K_H^{oil-air} = 0.332 + \gamma_w \cdot C_{pw} \cdot R_e^{0.5} \cdot P_{r_w}^{-2/3}$$

$$P_{r_w} = C_{pw} \cdot v_w \cdot \rho_w \cdot \left(\frac{1}{0.330 + 0.000848(T_w - 273.15)}\right)$$

$$R_e = \frac{v_{rel} \cdot \sqrt{\frac{4A_{oil}}{\pi}}}{\eta_w}$$

Type in the letters on behalf of:

C_{pw} —— The specific heat capacity of water;

P_{r_w} —— The number of Prandtl of water;

R_e —— The characteristic Reynolds number;

v_{rel} —— The viscous coefficient (in the process of the oil film movement).

3.3.3.5 Reflection and radiation

The oil film will lose and accept long wave radiation. Net amount of acceptation is calculated by the Stefan-Boltzman formula:

$$H_{total}^{rad} = \sigma \cdot (l_{air} \cdot T_{air}^4 + l_{water}\, T_{water}^4 - 2l_{oil} \cdot T_{oil}^4)$$

Type in the letters on behalf of:

σ —— The constant number of Stefan-Boltzman, σ =5.72×108W/(m2K);

l_{air} —— The radiation rate of atmosphere;

l_{water} —— The radiation rate of water;

l_{oil} —— The radiation rate of oil.

3.4 The Meaning of Understand the Principle of Oil Spill

After oil spill accidents happened, there were many physical and chemical processes, and also there were many factors influencing oil spill recovery. Understanding the related principles of oil spill is helpful to find the most effective treatment of oil spill, and, in the meantime, to ensure the recovery of oil spill effectiveness, timeliness and thoroughness. This chapter combines the next chapter to conduct an analysis of the oil spill risk source, which provides a theoretical basis of the emergency plan for the CNOOC (Huizhou) Logistics Base Wharf.

Chapter 4 Analyze the Cause of Oil Spill Accident

4.1 Introductory Remarks

According to the accident site, oil spill accident can be divided into the accident of broken ship and ocean structure and the accident of terminal operation. Besides, we can also classify leakage accidents according to the scene as is shown in figure 4-1.

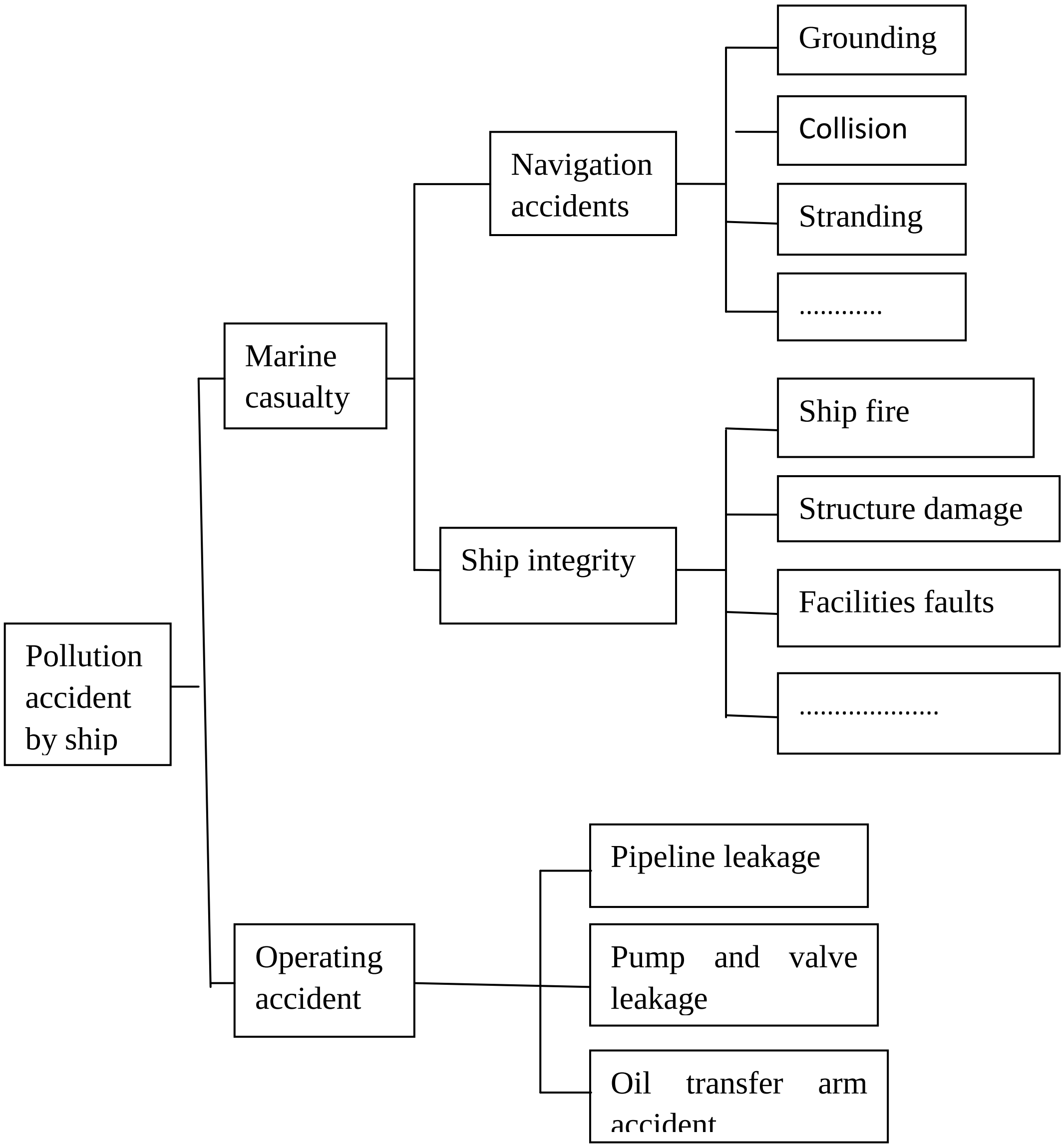

Figure 4-1: Classes of leakage accidents

According to the leakage accident of time, leakage accidents can be divided into three categories: 1) in anchorage ground during the anchoring; 2) sailing during the channel navigation; 3) berthing and unberthing including loading and unloading operations. In addition, the oil spill can be divided into persistent oil spill and non-persistent oil spill. The previous chapter described the bottom line of implementing an environmental policy from an economic point of view, but the theoretical illustration is far easier than the practical execution, which should consider the NSB at both global and national levels.

4.2 Operation Accident

Operation accidents can be divided loading/unloading oil, refueling, other works and illegal emissions according to the reason of the oil spill in each step. The cause of operational pollution accident is more complex, such as pollution accident happened at port during ship loading and unloading of goods, or equipped with fuel oil. Most of those accidents are due to human factors, the failure of machinery and equipment, etc. In addition, CNOOC (Huizhou) Logistics Base Wharf is an open wharf, especially in the monsoon season. If the wind is bigger, the cables will be snapped by wind when the ship is in dock, and the ship will not be controlled and may easily collide with the dock, thus resulting in oil spill.

4.3 The Ship and Ocean Structure Broken Accident

The accident of broken ship and ocean structure is usually accompanied by vessel traffic accidents, so the cause of the accident is approximately the same as that of vessel traffic accident. But at the same time, there will be oil spill due to collision, stranding, grounding, hull damage and fire explosion. The channel of CNOOC (Huizhou) Logistics Base Wharf is an artificial dredging waterway which is narrow and not deep. Usually, there are oil spill accidents due to the collision, bad weather, grounding and improper stowage. There are also large-scale oil spill accidents happening in the channel and anchorage.

4.4 The Place and Reason of Oil Spill Accident

According to statistics, the operation oil spill accidents usually happened in ports, and the ship and ocean structure broken accidents usually happened in the navigation channels and anchorage. The fire explosion accidents possibly happened in the dock, channel and anchorage. The possibilities on the cause of a typical oil spill accident cause and the location are shown in table 4.1.

Table 4.1: Accident Areas and Reason

Place	Source	Typical reason
Channel	Ship	Stranding, grounding, collision, rough sea (fog, typhoon), fire explosion, illegal emissions
Anchorage	Ship	Collision, oil spill caused by fire explosion
Harbor basin	Ship	Ship collision with another ship, or terminal, disoperation, oil spill caused by fire explosion
Wharf apron space	Dock	Loading and unloading, pipeline leakage in the process of oil operations, sluice valve leakage, disoperation, oil spill caused by fire explosion

Chapter 5 The Existing Oil Spill Response Plan of CNOOC (Huizhou) Logistics Base Wharf

5.1 Definition

Emergency response plan is in the face of emergencies such as natural disasters, major and extraordinarily serious accidents, environmental hazard and man-made sabotage of emergency management, command, rescue plan and so on. Generally, it should be on the comprehensive disaster prevention plans which include the following several important sub-systems, such as perfect emergency management command system, strong emergency aid security system, comprehensive coordination and responses of mutual support system, full disaster preparedness system of guarantee supply, etc. The duty of the emergency organization, personnel, technology, equipment, machine, goods and materials, rescue activities and command and coordination, etc is to make specific arrangements in advance. It is clear and definite which is the main responsibility unit and who is responsible in the different processes of sudden accidents. That is to say the different main responsibility units or responsible persons are responsible for the sudden accidents at different times. What to do? How to do? What strategies should be taken? In general, the emergency plan includes various government agencies such as the enterprises, government, community and the public, involving police, fire fighting, environmental protection, medical treatment, health media and so on.

5.2 Introduction on the Research Status of Chinese Emergency System

Although studies of emergency system has made certain achievements, yet in China, the applications of emergency system is still a separate sub-systems and is short of a unified and coordinated emergency mechanism with a unified platform.

At present, scholars in China have done a lot of work in the emergency management research. Some scholars have carried out the researches from laws and regulations, organization, decision making, operational mechanism emergency procedures and so on. For example, Wu Zongzhi has analyzed elements of major accident emergency plans, introduced the application method of enterprise accident emergency plan, and offered proposals of establishment of the major accident emergency rescue system; From the perspective of urban public emergency comprehensive emergency evaluation, Tian Yilin has established an urban public emergency response ability evaluation system, on the basis of system theory, the process management theory and system dynamics theory. Tian Yilin has studied of theory and methodology of emergency management of urban public emergency comprehensive ability evaluation index system.

However, in western developed countries, they started research and practice of emergency management theory earlier. In generally, they experienced disaster prevention from single to comprehensive, and then turned to the emergency management of gradual model, homogeneous model development process, through which they have accumulated a wealth of experience in theory and practice. The research and practice achievements are mainly embodied in the following several aspects: firstly, it pays attention to the construction of legal system, there is a whole system of laws and regulations system; Secondly, it emphasized the role of leadership: there is a head of government as the core, which includes the powerful central command system and the efficiency of crisis management system; Thirdly, great importance is attached to the communication of information, information collection, analysis, a set of agile information submission and disposal process. Besides, there is a specification of government crisis information release mechanism;

fourthly, the government vigorously popularized related knowledge, and the public have a strong sense of crisis and endurance capacity as well as trust in government. At the same time, there is some more deep research on the rapid response of the emergency response system abroad. Berman has employed the maximum coverage model of emergency location selection to improve the speed of emergency response and to construct the new transport of dangerous goods emergency network. Robinson has emphasized the role of expert system in emergency system. Sanjayjain has used the simulation model and the 3D visualization system to build a more perfect emergency system, and put forward the idea of establishing emergency response model and emergency simulation method. Furthermore, he has studied the visual problems of emergency system.

Compared with the situations abroad, there are certain gaps of emergency mechanism in China. It is mainly displayed as follows: firstly, there is short of a national emergency response mechanism on legal and policy basis; secondly, the government has no unified pollution emergency incident command or coordination organization. The management authority of environmental, sea and port pays more attention to the protection of the environment of marine pollution management than others, and the enterprises shall shoulder the responsibility of the pollution accident emergency themselves completely; thirdly, the government has no capability of pollution control. Only a handful of offshore oil development enterprises and harbor companies are equipped with a small amount of oil spill cleanup equipment. So in China, the emergency power is in a low level, and there is lack of coordination between each other, with a lot of pollution prevention equipment used repeatedly. For these reasons, it is not only difficult to cope with the huge accident effectively but also a serious waste of national financial and material resources.

5.3 Chinese Pollution Emergency Response System

Chinese water ship pollution contingency plans is used in the inland waters, territorial sea, contiguous zones of China, exclusive economic zones, continental shelves, and other sea areas under the jurisdiction of the People's Republic of China, Only in the event of a major oil discharge or leakage or poisonous and harmful material, does it require the other countries or regions to launch the pollution contingency plans. Four big sea waters' (including the South China sea, the East China sea, the Yellow sea, and the Bohai sea) pollution contingency plan and provincial pollution contingency plan are suitable for the respective jurisdictions. The above two levels of emergency plan has strong macro guidance which mainly focus on the coordination, command, specific operation implementation, and it needs to establish a plan on the basis of several levels. Port emergency response plan is for the intermediate level, according to the scope of application. Port emergency response plan is one of the most often launched the emergency plan, which has a strong maneuverability compared with the previous two levels of planning, but port emergency response plan also mainly focuses on the emergency command.

Given that several levels of the pollution contingency plan above have limitations, the terminal emergency plan is required to join the whole emergency plan. Therefore, the terminal emergency plan is a good support of the whole emergency system, and it is also a higher level of emergency plan to implement a foundation.

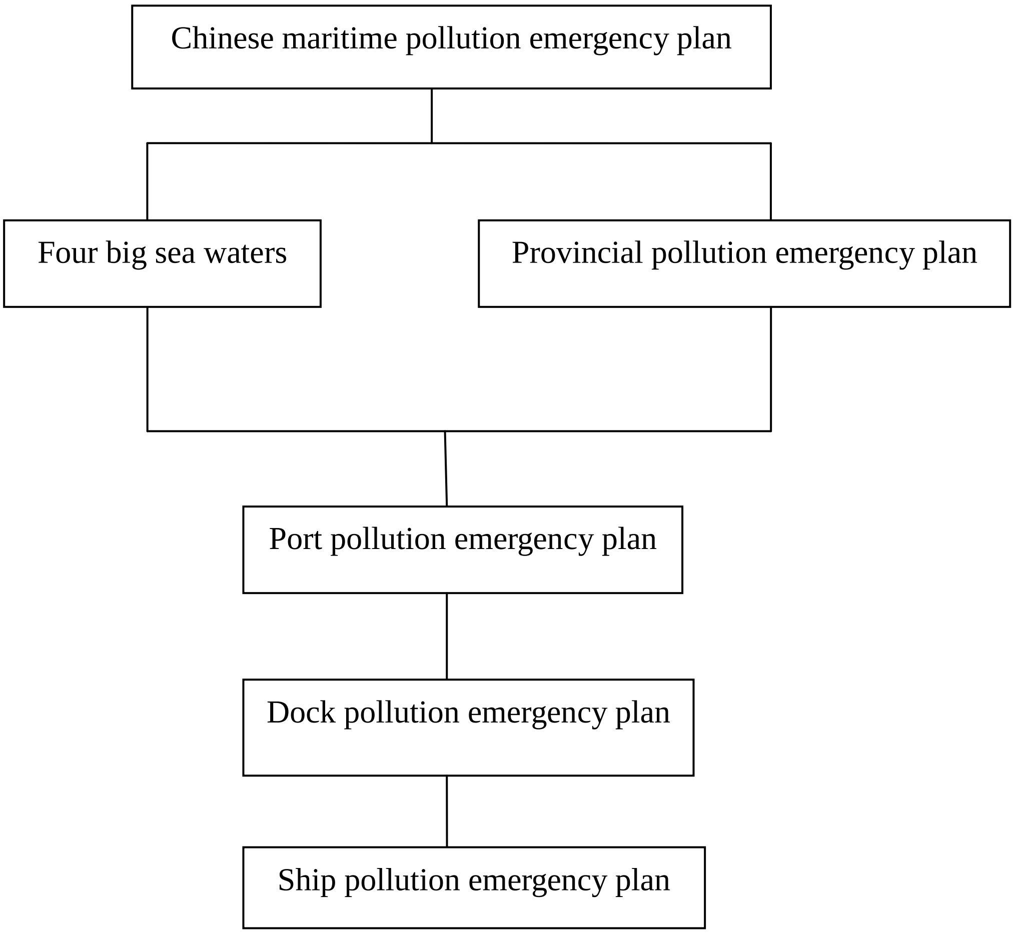

Figure 5.1: Five layers of Chinese maritime pollution emergency system

5.4 Introduction of the CNOOC (Huizhou) Logistics Base Wharf of the Emergency Manual.

The CNOOC (Huizhou) Logistics Base Wharf emergency manual is divided into three parts, Respectively, the CNOOC (Huizhou) Logistics Base Wharf comprehensive emergency plans, the CNOOC (Huizhou) Logistics Base Wharf special emergency plans and the CNOOC (Huizhou) Logistics Base Wharf site response plans. This manual contains the wharf of sudden accident emergency action procedures and ship at the wharf accidents emergency operation procedures, and determines the wharf and ship emergency organization, emergency program in emergency disposal and so on. Now the CNOOC (Huizhou) Logistics Base Wharf emergency manuals have been put on record in the maritime sector. The CNOOC (Huizhou) Logistics Base Wharf comprehensive emergency plans contain the main contents shown in the table as follows. The other two emergency plans are listed in the appendix.

Table 5.1: Main content of the CNOOC (Huizhou) Logistics Base Wharf comprehensive emergency plans

Chapter	Name	Content
Chapter I	General principles	Purpose of compilation Basis of compilation Scope of application Emergency response plan system Emergency work principle
Chapter II	The accident risk description	Company introduction Hazard identification
Chapter III	The emergency organization and responsibilities	The CNOOC (Huizhou) Logistics Base Wharf of emergency organization The emergency organization Main emergency personnel responsibility
Chapter IV	Early warning and information report	Early warning information reporting and disposal
Chapter V	Emergency response	Response at different level Response program

		Disposal measures End of the emergency Information publication
Chapter VI	Safeguard measures	Communication and information security Emergency teams to ensure Physical equipment support Financial guarantee Other guarantees
Chapter VII	Emergency plan management	Emergency plan training Emergency plan drills Emergency plan revision Emergency plan for the record Emergency plan implementation

5.5 Survey of the CNOOC (Huizhou) Logistics Base Wharf of the Emergency Resources

CNOOC (Huizhou) Logistics Base Wharf is equipped with oil containment boom of 500 meters, 5 tons of oil absorbent felt, 5 tons of oil dispersant, twelve combustible gas detection alarm system, one of single combustible gas detectors, eight waste oil collection barrels, numbers of personnel protective equipment and emergency communication equipment, and emergency equipment warehouses that have been erected in adjacent wharf stacking area. The emergency rescue team is equipped with 29 full-time emergency personnel. The specific contents of oil spill emergency facilities configuration are shown in table as follows.

Table 5.2: Equipment list of CNOOC (Huizhou) Logistics Base Wharf oil spill response

Equipment and material	Type	Equipped with number
Rope-type receive machine	SS10A	2
Disc-type receive machine	ZSY5	2
Hard brush-type receive machine	Minimax20	1
Boom	WGJ-1000	2000m
Oil absorption life line		800m
Dispersants sprayer	PS-40	2
Oil absorbent felt		5t
Oil dispersant		4t

5.6 Survey of the CNOOC (Huizhou) Logistics Base Wharf near Emergency Resources

Long Shan environmental protection Co., Ltd. was set up in 1995. Now there are main disposal facilities with annual processing capacity of more than 110.000 cubic meters of oil wastewater biochemical treatment system and 6.000 cubic meters of slop storage devices. The company is equipped with the oil spill emergency equipment warehouse, such as the receiving machine, oil boom, spraying device, temporary storage equipment, oil absorption material and oil spill dispersants and so on.

Shen Shen Da ocean engineering service Co., Ltd was set up in 2005. The company has participated in China's Marine oil spill emergency response qualification review and obtained the certificate of ship pollution clear unit level qualification (certificate number: 10-1010). The company is equipped with 2 professional emergency clean-up ships and 8 emergency auxiliary boats, as well as the oil spill emergency equipment warehouse.

Both companies have signed the "agreement of emergency response support and resource sharing" with the CNOOC (Huizhou) Logistics Base Wharf. Moreover, the CNOOC (Huizhou) Logistics Base Wharf has also signed the "agreement of emergency response support and resource sharing" with the ministry of communications of Guangdong Salvage Bureau, and reached an agreement on the use of aircraft and ships in case of massive oil spill accidents.

Chapter 6 Conclusions

In order to improve the success rate of the oil spill emergency disposal and reduce oil spill pollution losses to the minimum, when the emergency plans are made, the emergency plans should include the various handling of the oil spill, which also state the advantages and limitations of various kinds of processing mode. The study of the principle of the oil spill model is helpful to understand the physical and chemical changes of the oil film. After the occurrence of the oil spill, the principle of the oil spill model provides a theoretical basis for the oil spill emergency treatment.

The management of the CNOOC (Huizhou) Logistics Base Wharf has been standardized; the wharf has three levels of emergency plans. The CNOOC (Huizhou) Logistics Base Wharf has established the wharf safety operation and pollution prevention management system. The wharf management system, operating procedures, equipment management, personnel training and emergency plan are included in system management, to further promote the programming and standardization of the management. According to the survey, the CNOOC (Huizhou) Logistics Base Wharf has built a system of equipment maintenance update, safety equipment, emergency response equipment and pollution prevention facilities for regular inspection and maintenance. The CNOOC (Huizhou) Logistics Base Wharf has strengthened the supervision and management of ship refueling operation, before the ship's refueling operation, the oil tanker must fill out a form, and the wharf will send a full-time security officer to process supervision, and the entire refueling process is strictly monitored to prevent the oil spill accidents. Through daily training and exercises, the CNOOC (Huizhou) Logistics Base Wharf will further improve the wharf pollution prevention emergency plans, as well as improve the rationality and practicability of the emergency plans.

How to further reduce the number of oil spill accidents from happening? Firstly, it is necessary to note that strengthening the operational countermeasures is to prevent the oil spill accidents, which includes strengthening the education of wharf personnel guidance, management and operation. Personnel at the CNOOC (Huizhou) Logistics Base Wharf shall hold relevant certificates, and through training and contingency drills, they continuously improve the safety of wharf work and anti-fouling emergency disposal skills. When the oil spill accidents happen, they should follow the emergency plans and take appropriate actions. The safety education for wharf and vessel's operative personnel should be strengthened; strengthening the consciousness of anti-fouling and standardizing operational actions is to eliminate the oil spill accident caused by human factors. Secondly, it is well known that most average oil spill accidents are caused by human factors, so the CNOOC (Huizhou) Logistics Base Wharf is combined with shipping companies to strengthen maritime personnel training education in order to improve their operative skills and safety consciousness. Meanwhile, the crew should strengthen understanding the harm of oil spill accidents. Thirdly, the CNOOC (Huizhou) Logistics Base Wharf is combined with Huizhou MSA for supervising berthing and unberthing ships and strengthening navigation within wharf area and risk control. Shipping companies and the crew should sufficiently analyze and evaluate the working condition of power equipment. According to the emergency plans, early examination, early detection and early solution is to prevent the oil spill accidents caused by equipment problems. Finally, the CNOOC (Huizhou) Logistics Base Wharf should use modern monitoring equipment for real-time remote monitoring berthing and unberthing, loading and unloading process. Once the oil spill accidents appear, the wharf reaction will be in time to prevent the expansion.

REFERENCES

Anthony Ross & Cornelia Droge. (2002). An integrated benchmarking approach to distribution center performance using DEA modeling. *Journal of Operations Management,* (20), 19-32.

C.F.Hermann, ed. (1972). International Crisis: Insight from behavioral Research. *N.Y.: Free Press,* 44-47.

Feng S & Sun W X (1992). *Physical ocean numerical calculation*. Zhengzhou: Henan Science and Technology Press. 429-479.

Gu C. H. & Chen G. Z. (2001). Shallow discussion environment risk assessment and management. *The New Environmental Protection, 23*(4), 38-41.

Guo Y.W & Liu D & Zhong B C ed. (2008). The impact of wind on river oil spill drift and extend experimental research. *Journal of Hydrodynamics. 23*(4), 446-452.

Hu E. B. (2009). *The practical technology, methods of the environmental risk assessment and case.* Beijing: China Environmental Science Press.

Hu E. B. & Yao R. T. ed. (2004). Shallow discussion environment assessment. *Radiation Protection Bulletin.* (1).

Liu S.Y. (2005). *The emergency organization system inspection and decision-making* *process of the ship oil spill*. Unpublished master's thesis. Shanghai Marine University, Shanghai, China.

Liu W F & Sun Y L (2009). The movement numerical simulation method of oil spill study and improvement. *Journal of East China Normal University*. (3), 90-97.

Lu J. J. (2006). *Ningbo chemical wharf area environmental risk assessment and management.* Unpublished master's thesis. Dalian Marine University, Dalian, China.

Oded Bernana & Vedat Verterb & Bahar Y. Karac. (2007). *Designing emergency response networks for hazardous materials transportation.* Computers & Operations Research. (5): 1374-1388.

Ri chard Shultz & JR. And Stephen Sloan, ed. (1980). *Responding to the Terrorist Threat: Security and Crisis Management.* New York: Paragon Press. 134-173.

Robinson & Frank. (1986). *Expert system applied to problems in GIS introduction.* Environment and Urban System. (4): 161-173.

Sanjay Jain & Charles R. Mclean. (2003). *Winter Simulation Conference 1986.* New Orleans: Winter Simulation Conference. 1068-1076.

Stewart. R.J. & Devanney. J.W. (1973). *III. Bayesian Analysis of Large Oil Spills: An Erlang Sampling Distribution.* MIT Commodity Transport Laboratory Report MITCTL, Massachusetts Institute of Technology. (7), 73-166.

Sun W.W. (2006). *Overall evaluation of the oil tanker oil spill risk Dalian new port area*. Unpublished master's thesis. Dalian Marine University, Dalian, China.

Suter G W & Barnthouse L W & O'Neill R V (1987). *Treatment of Ruskin Environmental Entail Impact Assessment.* Environmental Management. 11(3)：295～303.

The General Office of the Guangdong People's Government. Guangdong marine oil spill emergency response plan. 2014.

The Ministry of Transport. The Regulations of the People's Republic of China on the ship marine environment pollution emergency preparedness and emergency disposal. 2011.

The State Council of the People's Republic of China. National major marine oil emergency plan. 2012.

The State Council of the People's Republic of China. National major marine oil spill emergency ability construction plan. 2012.

The State Council of the People's Republic of China. The regulation of prevention and control of marine pollution to the marine environment. 2011.

Wang C H (2000). A preliminary study on the oil spill drift diffusion calculation mode. *Transportation and Environmental Protection. 21*(2), 7-9.

Wu Z H & Zhao W X (1992). The oil spill of the extension, discrete and migration model. *Marine Environmental Science. 11*(3), 33-40.

Wu Z.Z. & Liu M.(2003). *An introduction to major accident emergency rescue system and preparedness.* Beijing: Metallurgical Industry Press.

Xiao J K.(2001). *Ship oil spill risk assessment model and application research*. Unpublished doctor's thesis. Dalian Marine University, Dalian, China.

Xu T (2010). Denmark MIKE21 model overview and application instance. *Water conservancy science and technology and economy.16*(8), 867-869.

Xu X. G. & Lin H. P. & Fu Z. Y. ed. (2001). The risk assessment of the Yellow River delta wetland regional. *Acta Scientiarum Naturalium Universitatis Pekinensis.* 37.

Yang F. & Yu J. X. (2004). Discussion south-to-north water transfer Project construction stage of the environment risk assessment. *China Water Resource, V(N): 30-32.*

Zhang W. X. (2009). *The engineering environmental risk assessment methods of petrochemical wharf.* Energy and Environment.66-88.

Zhuang X Q (2007). The oil spill numerical simulation and visualization technology. *Navigation of China.* (1), 97-100.

APPENDIX: A

Table 1: Main content of the CNOOC (Huizhou) Logistics Base Wharf special emergency plans

Chapter	Name	Content
Chapter I	Summary	
Chapter II	Oil reservoir area special fire explosion accident emergency plan	Purpose and definition The accident risk analysis Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures
Chapter III	Wharf fire explosion accident special emergency plans	Purpose and definition The accident risk analysis Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures
Chapter IV	The personnel casualty special emergency plans	Purpose and definition The accident risk analysis Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures
Chapter V	Vehicle accidents under special emergency plans	Purpose and definition The accident risk analysis

		Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures
Chapter VI	Lifting injury accidents special emergency plans	Purpose and definition The accident risk analysis Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures
Chapter VII	Stress injury accidents special emergency plans	Purpose and definition The accident risk analysis Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures
Chapter VIII	Wharf oil spill special emergency plans	Purpose and definition The accident risk analysis Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures
Chapter IX	Oil spill special emergency plans	Purpose and definition The accident risk analysis Emergency command organization and responsibility

		Emergency treatment procedure Emergency treatment measures
Chapter X	Ship accidents special emergency	Purpose and definition The accident risk analysis Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures
Chapter XI	Blackouts in special emergency plans	Purpose and definition The accident risk analysis Emergency command organization and responsibility Emergency treatment procedure Emergency treatment measures

APPENDIX: B

Table 1: Main content of the CNOOC (Huizhou) Logistics Base Wharf site response plans

Chapter	Name	Content
Chapter I	Wharf area production safety accident site response plans	Line, petroleum products, equipment fire, explosion site response plans Diesel oil pipe, flange, valve group leaking site response plans Diesel transfer arm and hosepipe falling off site response plans Drowning accident site response plans Ship fire and explosion site response plans Ship man-overboard accident site response plans Ship oil spill site response plans Ship accidentally collided with wharf or ship inclining site response plans Ship break cable site response plans
Chapter II	Oil storage production safety accident site response plans	Storage tank fire or explosion site response plans Oil spill site response plans

Chapter III	General production safety accidents site response plans	Surrounding facilities fire and explosion site response plans The other accidents site response plans