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Research on establishment of oil spill emergency response system in China Qingdao Port based on ANN

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RESEARCH ON ESTABLISHMENT OF OIL SPILL EMERGENCY RESPONSE SYSTEM IN CHINA QINGDAO PORT BASED ON ANN

By

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China

A research paper submitted to the World Maritime University in partial Fulfillment of the requirements for the award of the degree of

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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: **Research on establishment of oil spill emergency response system in China Qingdao port based on ANN**

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Marine oil spills is a serious environmental disaster, the majority are unexpected incidents. Since 1960s, ports of developed countries had established emergency response systems to prevent oil spills. In recent years, oil transportation in China kept continuously increasing. Qingdao port, as the biggest port of oil throughput in China mainland for tens of years, has a pivotal position in Chinese oil transportation. Since 1990s, partial ports in China had begun to institute oil spill contingency plans, and discussed the establishment of oil spill emergency response systems. However, Qingdao port is still lack of related activities. This is just the focus the proper thesis will study.

The proper thesis first introduces the fundamental information of oil spill emergency response systems. And, it analyzes the necessity of establishing oil spill emergency response system in Qingdao port. According to the analysis, we find that, in oil spill emergency response, oil spill grade judgment doesn't only affect the selection of oil spill operations, but also decides the scale and direction of emergency response activities. Only according to the accurate judgment of oil spill grades, we can establish a normally operational oil spill emergency response system. By applying ANN method, the proper thesis does scientific judgment on oil spill grades. At last, enclosing the accurate judgment of oil spill grades, the proper thesis finishes the establishment of oil spill emergency response system in Qingdao port. We hope this research can provide some reference to studies of port oil spill emergency response in China.

KEYWORDS: Oil spills, Oil spill emergency response system, Judgment of oil spill grades, ANN, Establishment of oil spill emergency response system

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LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
AOF	Administration of Ocean and Fisheries
AWS	Administration of Work Safety
BP	Back Propagation
DWT	Dead Weight Tonnage
F	Fatal Accident
G	General Accident
M	Moderate Accident
MSA	Maritime Safety Authority
N	No
NEPA	National Environmental Protection Administration
NSF	North Sea Fleet
R	Relatively Serious Accident
S	Serious Accident
US	United States
Y	Yes

1. Introduction

1.1 Background

With the steady increasing of oil consumption and transportation, marine oil spills from ships frequently happen. In recent years, oil transportation in China grows rapidly. Since 1993, China turning from oil-exporting country to oil-importing country, demand for oil reached 200 million tons per year. Qingdao Port has always been the largest import and export oil transit base of China coast in consecutive years, and is an accident-prone area. Between 1974 and 1999, there had happened more than 200 oil spills in Qingdao sea area, among which, for 11 times, the spilled volume of single accident was over 30 tons. Since 2000, with the constant improvement of Qingdao port navigation, gradually standardization of safety management and pollution prevention management of the world major oil tanker companies and the increasing capability of marine monitoring in Qingdao Port, the number of oil spills from ships relatively reduced, and oil spill volume also declined. But oil spills never disappear, and environmental safety situation remains grim.

With protection of the environment, taking the road of sustainable development is one of China's basic national policies. Oil spills will lead serious injury to the sea area of Qingdao port and marine environment of China, and it will also bring tremendous losses to ocean economics. Qingdao, as the outstanding one among coastal cities in China, should definitely put high emphasis on the ocean which it depends on surviving and developing. The situation of ocean environment directly affects the sustainable development of Qingdao port, and economic of the city. Therefore, research on oil spills prevention is a great meaning to Qingdao port.

After oil spills, quickly and effectively making the oil spill emergency response and taking emergency measures play a key role to control pollution, reduce the loss of pollution and decontamination. In emergency response, evaluation of oil spill grades will directly impact the operation of oil spills. The correctness will affect environmental protection strategy, arrangement of staff and equipments, efficiency and timeliness to deal with incidents, and so on. Applying advanced software technology to scientifically and effectively judging oil spill grades can provide sufficient evidences to compensations. And it also helps the MSA, government agencies and other units to establish oil spill emergency response systems, to increase the ability to operate sudden oil spills, and to accelerate the removal of oil pollution incidents and the restoration of the environment. The thesis will research on the establishment of oil spill emergency response system in Qingdao port, with enclosing oil spill grades.

1.2 Research content

The proper thesis has six chapters.

- Chapter 1, introduction, introduces background and research content;
- Chapter 2, literature review, introduces the definition of oil spill emergency response systems, oil spill emergency response systems at home and abroad, features of these systems, and the actuality of research methods of systems;

- Chapter 3, the necessity of establishing oil spill emergency response system in Qingdao port, points Qingdao port status in China, the huge oil spill risks existed in Qingdao port, and the problems of existing oil spill emergency response;
- Chapter 4, oil spill grade judgment based on ANN, introduces theory of BP network in neural network, system and quantification of oil spill judgment indicators, calculations and analysis of oil spill grade evaluation examples based on neural network;
- Chapter 5, establishment of oil spill emergency response system in Qingdao port, introduces the establishment of each part in Qingdao port oil spill emergency response system;
- Chapter 6, Conclusion, sums up the thesis.

The proper thesis first introduces the definition of oil spill emergency response system, oil spill emergency response systems at home and abroad, features of these systems, and the actuality of research methods of systems. According to introducing Qingdao port's status in China, the existing oil spill risks, and problems in existing oil spill emergency response measures in Qingdao port, it analyzes the necessity of establishing oil spill emergency response system in Qingdao port. In oil spill emergency response, oil spill grade judgment doesn't only affect the selection of oil spill operations, but also decides the scale and direction of emergency response activities. Only according to the accurate judgment of oil spill grades, we can establish a normally operational oil spill emergency response system. By applying MATLAB6.5 and quoting BP network, the most mature one of neural networks, the proper thesis does scientific judgment on oil spill grades. At last, according to the outcomes of grade judgment, we determine emergency response measures on different levels, confirm transfers of related cleanup equipments and staff, and finish the establishment of oil spill emergency response system in Qingdao port.

2. Literature Review

2.1 Definition of oil spill emergency response system

Emergency response of oil spills is, when oil is spilled into the water in accidents, the maximum measures are taken by the related departments in shortest time, to control and reduce the damages caused by pollutions. Management agencies, emergency groups, the contingency plan, and the accident compensation mechanisms are the indispensable parts of emergency response.

The abilities of organization and coordination in management agencies directly influence the effect of emergency response. As the undertakers of the contingency plan, staff in emergency groups influences the effectiveness of the contingency plan implementation. The contingency plan is essential to the emergency response, but whether it is implemented effectively, depends on the emergency response system's perfection.

The establishment and improvement of emergency response system are the requirements of implementing the contingency plan effectively and improving the emergency response capabilities. Different levels of contingency plans form different levels of emergency response systems. As the differences of tasks, high level emergency response systems focus on the organization and coordination of the overall situation, the rational allocation of resources, and the control of response activities. While, low level emergency response systems focus on the control and removal of the pollutions.

2.2 Comparison of oil spill emergency response system at home and abroad

2.2.1 Foreign oil spill emergency response system and features

1. Foreign oil spill emergency response system

Early in 1970s, developed countries gradually established and improved respective marine pollution emergency response mechanism. They mostly adopt 2-level or 3-level structure.

U.S. divides national oil spill emergency response system into 3 levels: national, regional, and local level. Each level owns respective contingency plan. And by establishing oil spill contingency plan, training and SPEARS, U.S. enhances capabilities of safe management, contingency plan and emergency response.

U.K. divides oil spill emergency response system into 2 levels. The first level is emergency response agencies on governmental-level, such as Sea Pollution Control Board. The other one is emergency response agencies on local level, such as local authorities.

French emergency system is made up of 2 subsystems，marine emergency and land emergency. Each subsystem is divided into 2 levels, governmental and local level.

Although organizational structures are slightly different, oil spill emergency response systems in Sweden and Australia, in principle, are formed by 2 levels, related departments directly under the government and local units.

As a whole, every port in developed countries has its own relatively completed contingency plan. Once oil spills happen, from port to nation, these systems will response by the level to deal with accidents.

2. Features of foreign oil spill emergency response system

All the developed countries’ emergency organizations have the following features in common.

a. The systems have completed legal systems, and take national contingency plans as leads. They set up multi-level emergency command and coordination agencies, such as national and local, and define the duties according to scopes of accidents. And, on the basis of groups and professional companies, the governments are deployed with a certain number of emergency teams and equipments.

b. Every country adopts 2-level or 3-level structure, taking government agencies as principle part of the whole organization. The structure is organized and operated by NEPA and related departments. Other related departments actively cooperate during the operation. The emergency organizational department makes full use of social resources, transfers civil antifouling power, and cooperates with enterprises and companies existing potential oil spills danger. All these activities enhance the establishment of oil spill antifouling ability.

c. No matter for 2-level or 3-level structure, each one usually composes management level and operation level. Management level plays a role as directing and coordinating, and operation level focuses on on-site cleanup work.

d. The emergency organizational structures of these countries all set up the most basic institutions, such as 24-hour oil spill alarm agencies and oil spill emergency command center which has the highest decision making right.

Meanwhile, we can find the differences of these organizational structures. Some countries depend on external professional remediation companies to complete oil spill cleanup work. Some countries deal with oil spills by the professional agencies of government. And some others combine both of the two forces to do operations.

For example, oil spill cleanup in U.S. is in the form of contracts to deal with. Cleanup work in France mainly depends on staff and materials from companies and public, and takes the form of temporary lease or requisition. Oil spill cleanup work and expenses in U.K. is burdened by the government.

2.2.2 Domestic oil spill emergency response system and features

1. Domestic oil spill emergency response system

At present, water oil pollution contingency plan in China can be divided into 4 levels. The highest level is National Marine Oil Spill Contingency Plan. The second is regional oil spill contingency plan, such as the contingency plans set up in several sea areas in 2000 by MSA of China, North Sea Area Marine Oil Spill Contingency Plan, Taiwan Strait Marine Oil Spill Contingency Plan, and South Sea Area Marine Oil Spill Contingency Plan. The third level is Port Oil Spill Contingency Plan of each port. The forth level is Ship Oil Spill Contingency Plan on board. All plans on each level are linked tightly and indivisible. Different level contingency plans form different level emergency response systems.

Qinhuangdao establishes oil spill response center and related oil spills material database. The oil spill emergency response system is area-port-quay 3 level. The port realizes unified deployment of marine remediation staff and material resources, establishes management system of oil spill emergency supplies, and ensures harmony use, which increases the oil spill emergency response ability.

Lianyungang Marine Oil Spill Contingency Plan, as part of national marine oil spill emergency response system, is the third level. It is below China Marine Oil Spill Contingency Plan and East Sea Marine Oil Spill Contingency Plan, and followed by quay oil spill contingency plan and oil Spill contingency plan on board.

Shenzhen marine oil spill emergency response system is one level system between sea area and port. It can deal with general oil spills, and works well.

2. Features of foreign oil spill emergency response system

Compared with developed countries, China doesn't have completed national or government emergency mechanism yet, which is reflected on the following 3 parts.

First, China is lack of legal and political base to establish national emergency mechanism. Since 1970s, China has issued a series of marine environmental protection regulations. But there are still no fundamental requirements on the oil spill contingency plans establishment and equipping relevant emergency equipments.

Second, governments don't have the unified pollution emergency commands or coordinated organizations. Related government departments focus on marine sewage management, and enterprises take care of emergency operations just by themselves.

Third, governments don't have ability to control pollutions. Only several harbor affair companies in China are equipped with a small amount of cleanup equipments. The level of emergency forces in China is relatively low. It is lack of coordination among ports. All ports, as dealing with oil spills on their own, don't have ability to solve large oil spills.

2.3 Actuality of research methods on oil spill emergency response systems

2.3.1 Actuality of research methods on oil spill emergency response systems among state

Although there are some differences of oil spill emergency response systems among states, all the systems are made up of four parts, emergency organization structure, emergency response process, emergency activity, and emergency resources.

Emergency response software system is the precondition of cleanup work. Developed countries put great emphasis on the establishment of emergency response software during establishing emergency response systems.

OSTM, as a part of Australia oil spill contingency plan, is to complete the simulation of oil spill activities and provide foundation to the contingency plan establishment. RIAM and COMBOS are the simulating software focusing on Japan Sea and Tokyo Gulf, which are the basis of Japanese oil spill emergency response system establishment.

OILMAP in U.S., OSIS in U.K., MS4 in Holland, and MU-SLICK in Belgium are the technical supports to the establishment of oil spill emergency response system in these countries. These software are mainly involves environment dynamics, oil spill activities and other prediction models.

In China, Zhujiang port set up the oil spill emergency response system on the basis of marine oil spills dynamic prediction system in Zhujiang sea area by Xiong Deqi.

With the development of oil simulating technology, many researchers begin to develop oil spill information management systems and intelligent systems, on the basis of existing oil spill activity simulations, which provide more scientific evidences to establishment of oil spill emergency systems.

In the establishment of oil spill emergency response system in Dalian port, Xiong Deqi adds the geographical information, related to geographical environment and sensitivity in oil spill regions, into the existing oil simulating system.

Oil spill emergency response system in Zhoushan port is on the basis of Zhoushan oil spill simulating information system by Sunjun, consulting the oil track simulating software OLIMA of ASA (Applied Science Associates, Inc.).

The oil spill intelligent information system, is relatively completed software, developed by Qiao Bing and used by Shenzhen MSA.

Evaluation of oil spill grades belongs to oil spill emergency response software system, which directly affects the scientific judgment and accuracy of oil spill emergency decision making. However, the research methods of ports above rarely refer it. The proper thesis will take the oil spill grade judgment as the basis, and establish Qingdao port oil spill emergency response system.

2.3.2 Actuality of oil spill grade judgment

When oil spills occur, first we need to get the related information of accidents, investigate, and collect the data of oil performance, oil volume and polluted regions. Then, we should ensure the polluted evaluation and oil spill cleanup measures. In the process of dangerous extent evaluation, selection of indicators is particularly important, which determines the accuracy of oil spill grade judgment. Because the operational decision making mainly depends on the evaluation of adverse effects to environment by oil spills.

London of U.K. evaluating the oil spill effects is mainly on the basis of oil spill volume. And according to the oil spill volume as indicator, oil spills are divided into six levels from tiny to fatal level.

In 1990, W.Koops from Holland provided DLSA model to judge the grades of oil spills. He used 9 indicators to evaluate oil spills, oil toxicity in water, accumulating of biology, persistence of oil, toxicity in air, danger of explosion, danger of burning, radioactive damage, corrosive damage, and carcinogenic danger.

The former one evaluates the pollution extent by oil self characteristics, which is just a part of oil spill grade judgment. The latter, on the basis of the former, provides some other indicators effecting oil spill grades according to outside factors, which is relatively accurate to the grade evaluation.

But both of the papers don’t consider the effects of weather and ships to oil spills. Weather and ship types are greatly influence the oil spill threat extents. Good weather can help control oil spills. Tankers with potential oil spill risks, when loading huge amount of oil, are hard to control during accidents. Wind, wave, and flow also influence operations of the oil recovery equipments and the effects are different according to different types of equipments.

Above all, the factors effecting oil spill threat extent are many, and they link and affect with each other. The proper thesis will select damage of ships, age of oil spill ships, ship tonnage, ship type, weather, combining with oil spill volume, oil spill position, oil toxicity, flammability, and persistence, these ten factors as indicator system of oil spill grade judgment. We classify and quantify each of the indicators by mathematics method, and use neural network model. We judge the oil spill grades by multi-factor method, hoping to get a relatively completed evaluation.

3. The necessity of establishing oil spill emergency response system in Qingdao port

Establishing oil spill emergency response system is very necessary, which is directly related to the ocean environment and the future development of Qingdao port. This chapter will analyze the necessity of establishing oil spill emergency response system in Qingdao port according to five facets. All facets obviously show the urgent need to do the establishment.

3.1 Analysis of oil transportation in Qingdao port

3.1.1 General situation of Qingdao port

Qingdao port was built in 1892, with history of 115 years. It is one of China's key state-owned enterprises, China's second-largest port handling throughput of 100 million tons on foreign trade, one of important international trade ports on Pacific west coast and a key sea transport hub.

Qingdao geographical coordinate is N36°04′00″，E120°19′5″. (See Figure 3.1) Qingdao port sector is divided into two parts, waters and land. Qingdao port is no siltation all year round, ice-free, and the location and natural conditions are superior. It’s a rare natural deep water harbor in China.

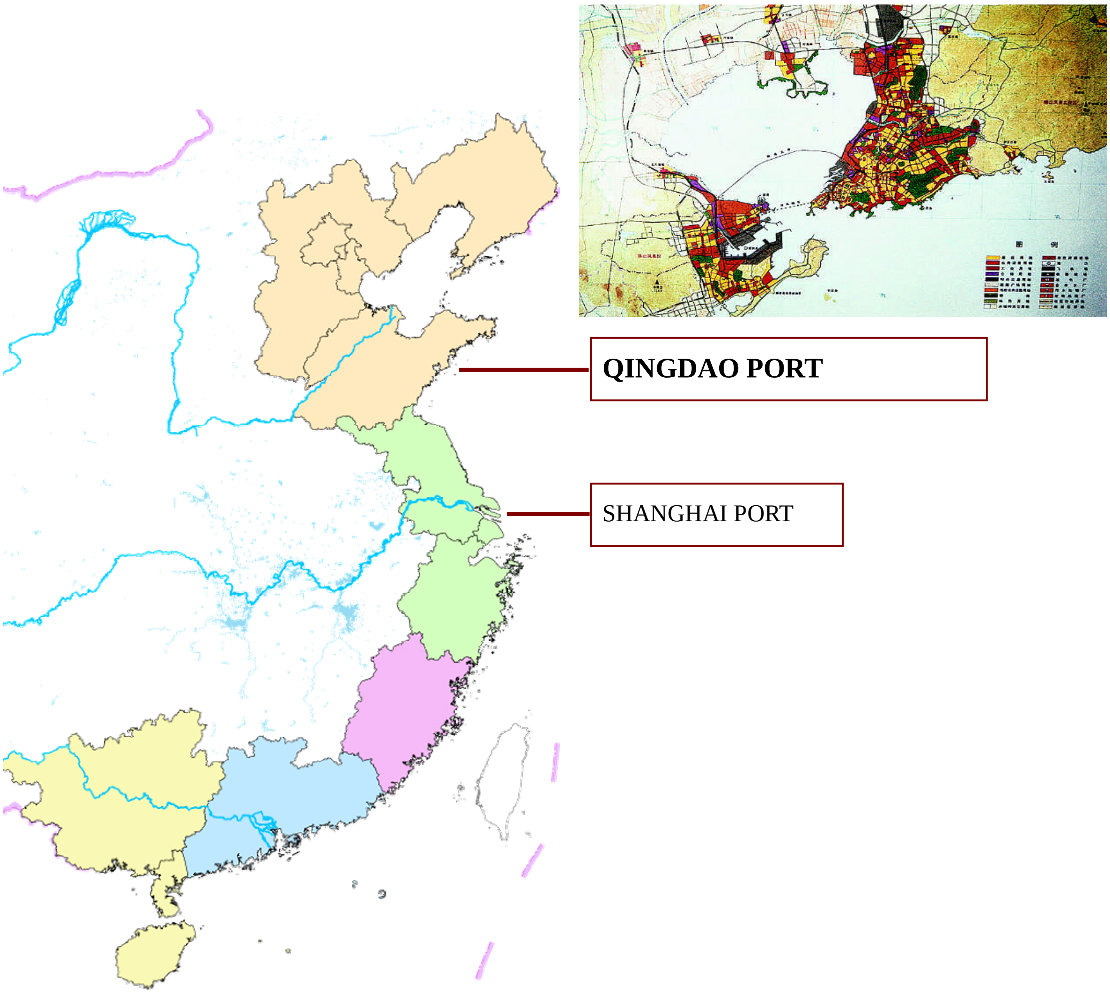

Figure 3.1- Position of Qingdao port

Source: Jiaozhou Bay Map. http://www.laitour.com/n49480c84.aspx

3.1.2 Oil transportation of Qingdao port

Qingdao port, as one of the important ports in North China, keeps rapid developing always. In recent years, oil throughput continuously develops, which makes Qingdao port steadily be the top one among China ports. We have searched some information of oil throughput in Qingdao port from internet, port materials, and port conference records. And we tidy the data up. (See Table 3.1 and Figure 3.2)

Table 3.1- Oil Throughput in Qingdao Port

Source: Qingdao Port. http://www.qdport.com

Year	1994	2000	2003	2004	2005	2006
Million Tons	12	23.87	25.85	31.06	33.54	39.07

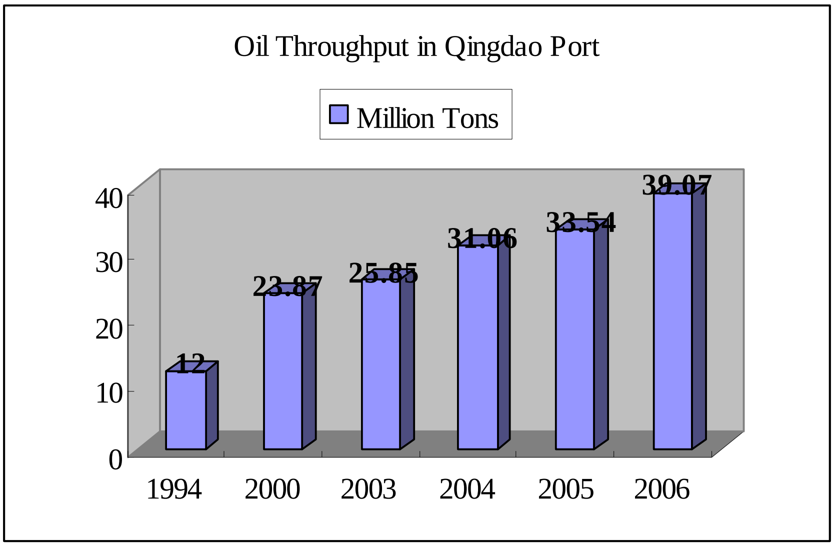

Figure 3.2- Oil throughput in Qingdao port

Source: Qingdao Port. http://www.qdport.com/

Qingdao port owns the 200,000-ton quay, which is the biggest crude oil transfer quay in China Mainland, and 1,000,000m^3 steel floating roof tank groups. Qingdao port is equipped world's advanced oil transportation systems and measurement devices, with pipeline access capability of above 10,000m^3 per hour. Qingdao port can berth 300,000-ton super tankers, and it used to successfully load and discharge 322,000-ton super tanker "Bankers". Between 2000 and 2005, the adding up crude oil imports loaded and discharged in Qingdao port take 18% of the total crude oil imports in China. Thus, Qingdao port plays a key role in China oil transportation.

3.2 The huge risks of oil spills in Qingdao port

3.2.1 Oil spill risks from ships

As the increasing number of ships accessing Qingdao port and density of navigation, it is easy to cause collisions, groundings, fires, explosion with oil spills occurring.
On 1986 Oct.18th, "Daqing No.245" of Guangzhou shipping department exploded in Huangdao port, spilled more than 100 tons oil, and polluted shoreline 100 km long; On 2001 Sep, Kuwaiti tanker "Shamidui" loading 260 thousand tons crude oil, cracked in the hull when entering Qingdao port. According to statistics, 2005-2006, there totally happen 17 oil spills in Qingdao port, as collision, grounding, or damage of hull.

3.2.2 Oil spill risks of tankers

As the increasing volume of oil transportation and number of large tankers, Qingdao port has risks of serious oil spill accidents.

In 1974, Chinese tanker "Daqing 31" grounded in the harbor, which leaded 900 tons of oil to spill out.

On 1979 June.23rd, Brazilian tanker "Kabes Cyrus President" shattered pipeline in Huangdao port, leading to oil spills 355.35 tons. Coastal beaches, the reefs were seriously polluted, oil sewage poured into seafood breeding ponds and farms, leading all scallop larva, sea cucumber larva, and some of the prawn die. The total loss reached 1.5 million RMB.

On 1983 Nov.25th, Brazilian tanker "East Ambassador" grounded at Zhongsha Reef in Qingdao port, spilled 3343.6 tons oil, and polluted 320 km shoreline of Jiaozhou Bay. The most serious sector was 4.7 km long, and the area was 147 thousand km2. The shore and reef of tourism attractions were polluted as 900 thousand km2. The loss was 17.75 million RMB (included loss in aquaculture).

On 1984 Sep.28th, Brazilian tanker grounded at Zhongsha Reef, and spilled 757.5 tons oil. The polluted shoreline was 103.3 km long. The accident increased the serious extent of Jiaozhou Bay environment; On 2005 July, Singaporean tanker "Titan Giants" spilled oil, which leaded dozens of tons of cargo oil to pour into sea.

3.2.3 Risks of oil spills and explosion on oil storages

The storage devices of oil in Qingdao port are under-developed, which are easy to spill oil or explode.

On Aug.8th, 1975, 200 tons oil spilled from Huangdao terminal station of Shengli Oilfield; On 1980 Oct.8th, oilcan of Qingdao fertilizer plant spilled 60 tons oil, and polluted Jiaozhou Bay and Hongshiya mussel breeding district, which caused serious losses to fishery and aquaculture; On 1989 Aug.12th, No.5 can of Huangdao oil storage exploded, then caused No.1 to No.4 explosion, with crude oil spills more than 630 tons, and polluted large area of Jiaozhou Bay and 130 km shoreline.

After suffering so many oil spill accidents, the ocean environment of Qingdao port is damaged to a large extent. And now, with the steady increasing of oil transportation, Qingdao port exist larger potential risks. If we don't take any measures to prevent oil spills, there will be fatal consequences.

3.3 Lack of contingency plan and mechanism

Establishing oil spill contingency plans is to fulfill the requirements of International Conventions. China is member of OPRC90 Convention and MARPOL 73/78 Convention. Both of the two conventions require ships, oil loading and discharging devices, and ports to establish contingency plans, and equip enough decontamination facilities. Establishing oil spill contingency plans is the requirement of Marine Environmental Protection Law, whose 69th rules that, oil loading and discharging ports, quays, stations, and ships must establish oil spill contingency plans, and equip related oil spill emergency devices and facilities.

As Chapter 2 has mentioned, Chinese government classify oil spill contingency plans into 4 levels, and has promulgated national and sea regional oil spill contingency plans. (See Figure 3.3)

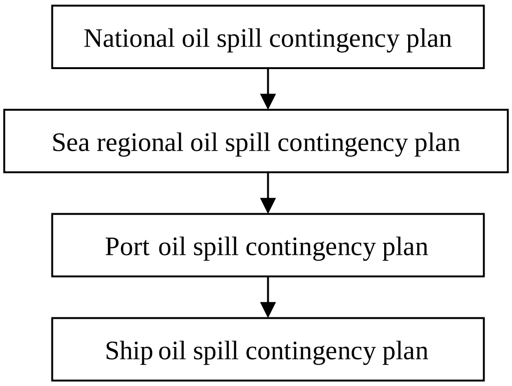

Figure 3.3- Four levels of oil spill contingency plans in China

Now many ports in China haven't established their own oil spill contingency plans. So does Qingdao port. General oil spill accidents depend on ship oil spill contingency plans, and fatal accidents use sea regional oil spill contingency plans. While, there exists a clear disjunction. Once non-fatal oil spills happen, ship oil spill contingency is not applicable, and if we start sea regional contingency plan, it will be a great waste, on either staff or materials.

Also, the extents of pollution and measures from different level oil spills are different. If a port contingency plan is unilateral, it will be hard to implement. Thus, when establishing port oil spill contingency plans, we should consider in the round, and take different measures against different level accidents.

Meanwhile, ports in China generally don't have the specialized departments for emergency response. Qingdao port just doesn't have the unified pollution emergency command or coordination organization. Because of the distemperedness of emergency response command and coordination mechanism, and slow progress and weakness of emergency response measures, the overall effect of oil spill disposal in Qingdao port is relatively bad.

Above all, the structure of oil spill emergency response is not sufficient and emergency response mechanism needs improving.

3.4 Insufficiency of emergency response

When oil spills happen, the emergency response is taken as Figure 3.4.

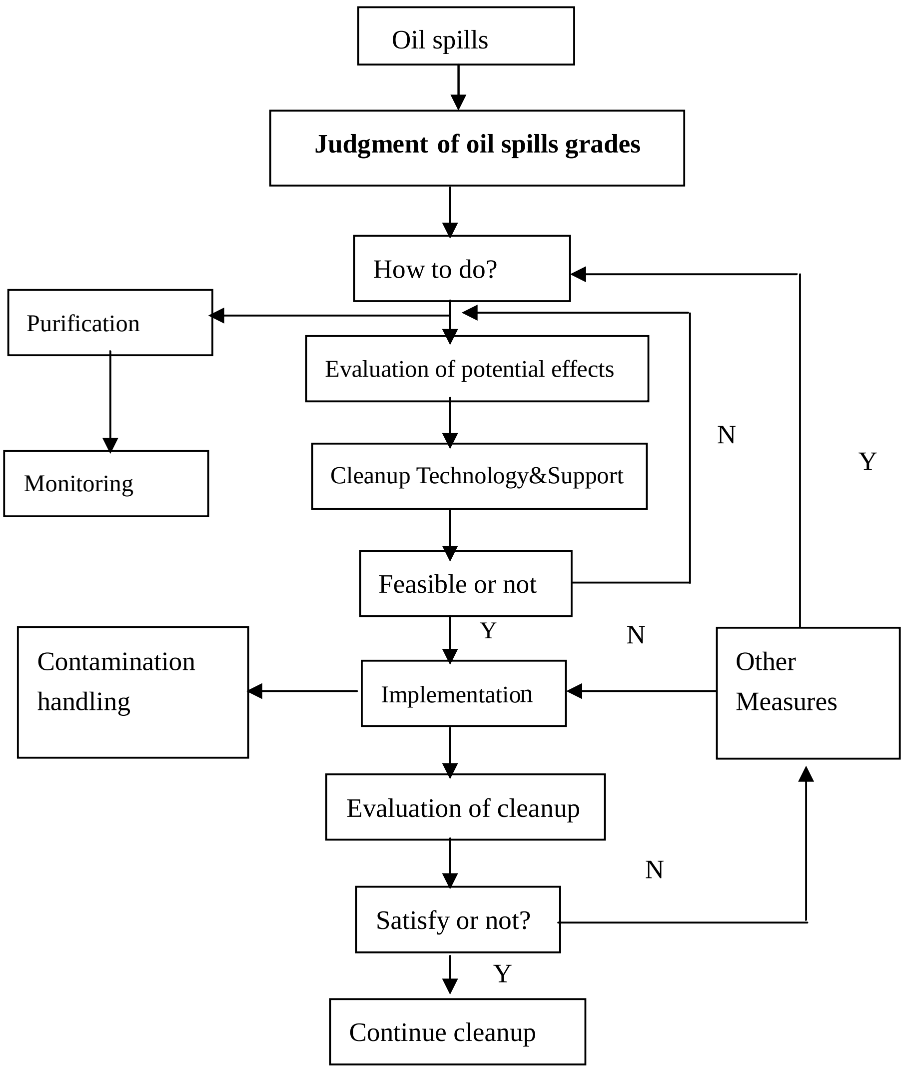

Figure 3.4- Structure of oil spill emergency response

Source: Zhao, J.Q., Deng, S.X. (1995). Assessment of oil spill effects and Decision of cleanup. *Environmental Protection in Transportation, 17 (1), 11-16.*

According to Figure 3.4, we can find the first step to do emergency response is to do the accurate evaluation of oil spills. This evaluation depends on software. Emergency response software is the initially important part of oil spill emergency response system. Without it, we don't know the oil spill grades, and we also don't know how to take measures to deal with oil spills. The whole emergency response can't progress. Developed countries all have advanced oil spill emergency response software in their emergency response systems. But, software in China doesn't develop well. As lack of support from emergency response software, when dealing with oil spills, Qingdao port is hard to gain high accurate and timely data, which will affect the efficiency of the whole oil spill disposal, and may even lead more serious pollutions to sea areas. Therefore, emergency response software is the absolutely necessarily part, and it also plays a key role during the oil spill emergency response. We will research it further more in Chapter 4.

3.5 Lack of emergency equipments and staff

At present, Qingdao port only has a small amount of equipments for preventing pollutions on sea, such as barriers, skimmers, sorbent materials, dispersants, and skimmer vessels. With these equipments, Qingdao port can deal with small scale oil spill volume. But facing large scale oil spills, Qingdao port will be helpless.

An emergency group with effective organization command and quick response is the key point to successfully deal with oil spills. However, qualities of emergency staff and command personnel are mixed. The marine oil spill emergency group in Qingdao port is mainly made up of part-time personnel of MSA, harbor affairs, salvage departments, oil quays, oil stations, and cleanup companies, which is lack of professional emergency response capability. When serious oil spills happen, the group can't be effectively organized to take measures. And, lack of training and drilling, the group can’t satisfy the increasingly strict requirements of preventing oil spills from ships.

Above all, according to the important status of Qingdao port in Chinese oil transportation, and the huge oil spill risks Qingdao port facing, there is a great necessity to establish oil spill emergency response system in Qingdao port. But, nowadays, there are some problems existing in emergency response of Qingdao port. It is obvious that, if we want to build up a completed and well-operational oil spill emergency response system in Qingdao port, we must solve the relative problems during establishment.

4. Oil spills grade judgment based on ANN

4.1 Theory of BP neural network

4.1.1 Introduction of neural network

ANN is a research field of simulation of the human brain thinking. ANN belongs to soft computing, an effective calculation method, which is just for very similar but not exact solutions. In modern operational research, soft computing occupied a very important position. Genetic algorithms simulated annealing, as well as "back-propagation algorithm" to solve many problems in operational research field play an important role. “Back Propagation Algorithm" is a Soft Algorithm of ANN algorithm, BP algorithm for short, raised by Rumelhart and McClelland made in 1986. In the composition of BP algorithm, nonlinear theory and methods in operational research are used. Moreover, the algorithm is optimal content, and can solve some operational research problems in complex systems, such as forecasting, control, and so on.

4.1.2 Theory of Back propagation NN

Back Propagation NN is a one-way transmission of multi-layer forward networks, whose structure is shown in Figure 4.1. In addition to the network input and output nodes, there are one or more layers of hidden nodes, without any coupling in the same layer of nodes. Model input from the input layer nodes came across the hidden nodes in turn, and then spread to the output nodes. The output nodes of each layer only influence the next output of layer of nodes. The node (transfer function) is usually Sigmoid - f (x) =1/ (1+exp (B x)) (B>0), but in the output layer, node module characteristics are sometimes linear.

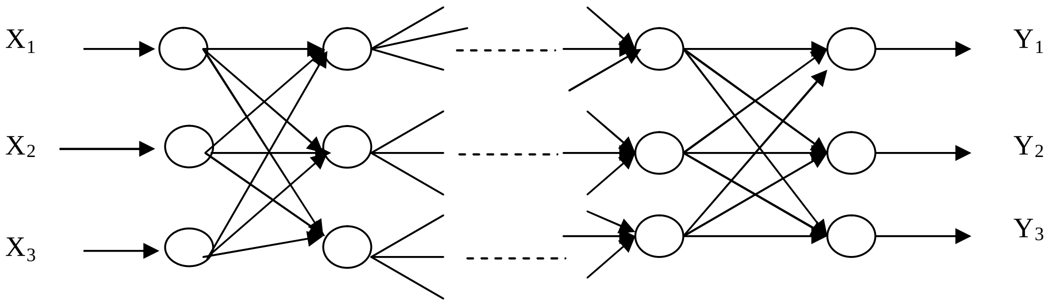

Figure 4.1- Structure of BP network
Source: Wang, W. (2004). *Calculation of Neural Network*. Higher Education Press.

1. BP algorithm flow structure (see Figure 4.2)

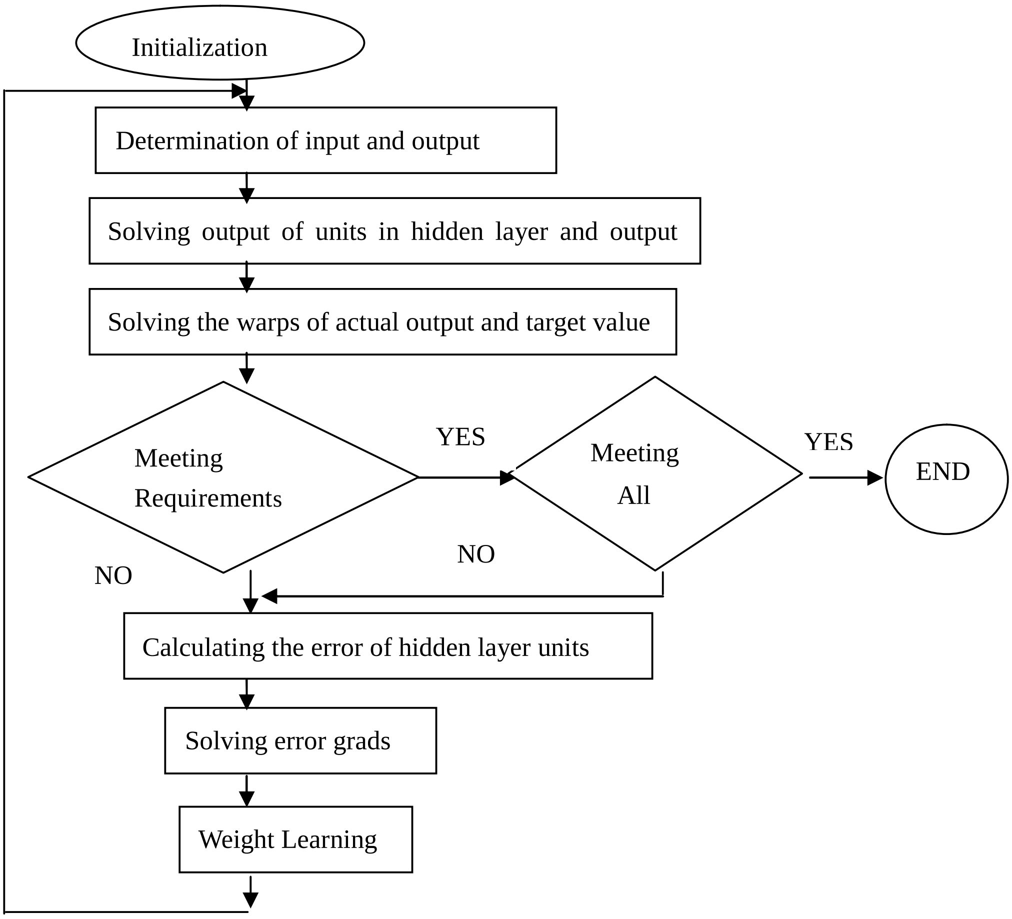

Figure 4.2- BP algorithm flow diagram

Source: Li, J.C. (1996). *Neural Network Theory*. Xian: Xian Electronic Science and Technology University.

2. Improved Algorithm

Toolbox of neural network, focusing on BP algorithm introduces several types of functions to train BP network, such as trainbpx and trainlm. Trainbpx takes the methods of additional momentum and adaptive learning efficiency to increase learning speed and reliability of arithmetic. Momentum method slows the sensitivity of partial details in error surface, which efficiently inhibits grid into partial minima. Adaptive learning efficiency method helps shorten the learning time. And trainlm uses Levenberg-Marquardt optimal method, which further shortens the learning time. Therefore, the thesis adopts function trainlm with short and effective learning time.

3. Determination of number of neural network layers and the middle layer neurons units

Generally, there are no theory evidences to take more than two middle layers. For most practical problems, one middle layer (3 networks) is enough. According to experience, we haven't found any advantage by taking more than 2 middle layers. The more middle layers we use, the longer the learning time takes. The reasons are as follows.

a. More middle layers will make the calculation of difference's back propagation process more completed, and learning time highly increase.

b. If number of middle layers increases, partial minimum difference will also increase. During the training process of network, the weight of network is easy to get into partial minima, and hard to adjust to the minimum.

4.2 Qingdao oil spills assessment system and quantitative indicators

4.2.1 Oil spills assessment indicators and their quantization

When using ANN to judge marine oil spills, we should firstly ensure the factors which affect the threat extents of oil spill. As these factors are the input layer of neural network, we classify them, quantify them, and restrict the value between 0 and 1.

1. Oil spill volume

Generally, the volume is larger, the threat extent is greater. The thesis divides volume into 6 levels. 0-40 kg is tiny accident, 40-330 kg is little, 330kg-1t is moderate, 1-50 t is big, 50-250 t is severe, and more than 250 t is fatal level. The relevant value is, 0-0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8, 0.8-1, and 1.

2. Integrated Sensitivity

Oil spill positions can be divided into sensitive and non-sensitive areas. If oil spills happen in sensitive areas, the threat extent is higher. Sensitive area can be classified according to its unique, danger, damage, economical value and season.

a. Unique

Unique means the specialization and importance of the program we evaluate. If some resource is especially important in the whole nation, the sensitivity is definitely high. If it is only important in some region, the sensitivity is moderate. And if it is only important in local area, the sensitivity is low. The sensitivity is divided into 3 levels, low, moderate and high by unique. The values are, 0.1-0.3, 0.4-0.7, and 0.8-1.

b. Dangerous

Dangerous is the possibility of pollution and the degree of withstanding pollution for sensitive regions. For sensitive regions such as aquatic resources regions and nature resources regions, the ability to withstand pollution of biology determines the dangerous of oil spills. The shoreline features and practical value of beaches and tourist areas determine their sensitivity to the oil spills. The sensitivity according to dangerous is divided into 3 levels, low, moderate, and high. The values are 0.1-0.3, 0.4-0.7, and 0.8-1.

c. Loss

Loss is the potential damage by pollutions. The loss evaluation is directly related to economical value, unique, and other value. It is divided into low, moderate and high level. The values are 0.1-0.3, 0.4-0.7, and 0.8-1.

d. Economical value

Economical value is not included in the integrated sensitive value, and it is just a reference of loss evaluation.

e. Season

Season is not included in the integrated sensitive value. And it is a reference to classification of unique, dangerous and loss in sensitive regions.

Above all, we give each the three sensitivity indicators a relative weight, which is to show the relative importance of the indicator in oil spills. Suppose unique, dangerous and loss as r_1, r_2, r_3, the relative weights of them are φ_1, φ_2, φ_3, and they satisfy the following relationships.

$$\varphi_1 + \varphi_2 + \varphi_3 = 1$$

Then, the integrated sensitivity is,

$$TS = r_1 \bullet \varphi_1 + r_2 \bullet \varphi_2 + r_3 \bullet \varphi_3$$

3. Oil properties

Oil properties level can be divided by toxicity, persistence, and flammability. Toxicity is the measurable indicator of impact to biology in oil spill regions, and reflects the possible threat of oil spills. Persistence is to measure the time of oil existing in the ocean. Flammability represents the possibility of spilled oil burning. The three indicators represent threat extent of oil spills according to different facets.

a. Toxicity

Oil toxicity tests show that, in most cases, toxicity of oil products and soluble derivatives of aromatic hydrocarbon in them is direct proportion. Toxicity of refining oil, such as gasoline and kerosene is higher than that of crude oil. Quantify the toxicity of oil. 0.7-1.0 is high toxicity oil, such as gasoline, light kerosene, and oil with more aromatic hydrocarbon. 0.4-0.6 is moderate toxicity oil, such as heavy kerosene, heavy oil with less aromatic hydrocarbon. 0.1-0.3 is low toxicity oil, such as heavy oil almost insoluble in water or non-aromatic hydrocarbon.

b. Persistence

Oil is a production of natural substances, which is easy to be oxidative degraded or biodegraded. The degradation depends on several factors, such as oil thickness, light intensity, ventilation, and the attaining conditions of nutrition. According to oil chemical nature, the smaller the oil molecular weight, the stronger the volatility is, and the weaker the persistence is. But the volatility of oil with more aromatic hydrocarbon is also strong. Persistence of light oil, such as gasoline and kerosene, is very weak. Quantify the persistence of oil. 0.7-1 is long persistence oil. For example, heavy oil is easy to be emulsified to solid, which will exist for a long time. 0.4-0.6 is the moderate persistence oil, such as heavy kerosene and light crude oil, with part emulsification, and part volatility. 0.1-0.3 is short persistence oil, such as gasoline, and light diesel oil.

c. Flammability

Flammability is classified according to the temperature of flash point. Gasoline, with flash point below -18℃, is taken as flammable liquid. Kerosene, with flash point 23℃-61℃, is relatively flammable liquid. While heavy oil is non-flammable products. Quantify flammability of oil. 0.7-1.0 is high flammable oil, such as gasoline, light kerosene. 0.4-0.6 is moderate flammable oil, such as heavy kerosene and light crude oil. 0.1-0.3 is low flammable oil, such as heavy oil and heavy crude oil.

4. Ship status

Ship status can be considered according to four facets, damage of ships, age of ships, tonnage, and type.

a. Damage of ships

Small-scale damage, which means the ship doesn't lose navigation capability and ability to control oil spills, is quantified as 0.1-0.3. Moderate-scale damage, which means the ship doesn't totally lose navigation capability and ability to control oil spills, is quantified as 0.4-0.7. Large-scale damage, which means the ship totally loses the capabilities or sinks, is quantified as 0.8-1.

b. Age of ships

New ships means ships are used for a relatively short time, and own advanced equipments which can deal with a certain amount of oil spills. The age level is quantified as 0.1-0.3. Moderate age ships, are used for relatively long time, and own the equipments not satisfying Pollution Convention, but own good obturations of cabins. The age level is quantified as 0.4-0.7. Old age ships are the ships close to or exceed the use life. The equipments are old, and obturations are bad. The age level is quantified as 0.8-1.

c. DWT

With the development of shipbuilding, ship tonnage is larger and larger. We classify and quantify the ships into three levels. Small level is 0.1-0.3, moderate level is 0.4-0.7, and large level is 0.8-1.

d. Types

According to the flexibility and the threat to oil spills, we classify and quantify the ships into three levels. High threat level is 0.7-1, such as liquid ships, such as tankers, LNG, and LPG. Moderate threat level is 0.4-0.6, such as barges. Low threat level is 0.1-0.3, such as bulk ships and container ships.

5. Weather

When oil spills occur, bad weather will affect the oil spill cleanup work. And the wind and billow will interrupt the operations. So, we quantified weather as follows. 0.8-1 is fog and gale weather. 0.7-0.4 is wind weather with slow speed. 0.1-0.3 is good weather.

6. Quantification of output indicators in ANN

The purpose of setting up a neural network by training samples is to practical application, which is to judge the grades of oil spills. The threat extent is uncertainty. We consider all the factors related to oil spills, and make a qualitative division. The five levels are general, moderate, relatively serious, serious, and fatal level. As the output of neural network, the values are quantified as 0-0.1, 0.2-0.3, 0.4-0.6, 0.7-0.8, and 0.9-1.

We can judge the degrees of training samples by the following additional evaluation criteria.

a. Fatal accident

- Oil spills exceed 330 kg with high toxicity in sensitive regions;
- Oil spills exceed 250 tons in popularly sensitive regions;
- Oil spill ship tonnage is large, and oil is high flammability;
- Age of oil spill ship is old, and oil is long persistence;

- Oil spill ship is a tanker, and the weather is bad for operation.

b. Serious accident

- Oil spills 40-330 kg, with high toxicity in sensitive regions;
- Oil spills 50-250 tons in popularly sensitive regions;
- Oil spills exceed 330 kg, with moderate toxicity in aquaculture areas.
- Age of oil spill ship is old, and oil is low persistence.

c. Relatively serious accident

- Heavy crude oil spills 0-40 kg, with high toxicity in aquaculture areas;
- Oil spills 40-330 kg in aquaculture areas, with low toxicity;
- Oil spills 1-50 tons in popularly sensitive waters;
- Light oil spills 40-330 kg in sensitive areas, such as nature reserves;
- Tanker tonnage is moderate level, and spilled oil is high flammable;
- Age of ship is moderate, and spilled oil is long persistence.

d. Moderate accident

- Crude oil spills 0-40 kg in aquaculture areas, with moderate toxicity;
- Tanker tonnage is small, and spilled oil is high flammable;
- Light oil spills 0-40 kg in sensitive areas;
- Oil spills 330 kg-1 ton in popularly sensitive areas;
- Age of ship is moderate, and spilled oil is low persistence.

e. General accident

- Other type ships, such as container ships and bulk ships, spill oil in good weather;
- Oil spills 0-330 kg in popularly sensitive areas;

- Tanker tonnage is small, and spilled oil is low flammable;
- Age of ship is young, and spilled oil is low persistence.

4.2.2 Qingdao oil spills indicators quantization

The proper thesis quantifies the indicators according to the criteria and the oil spills of Qingdao port in 2005 and 2006.

The weights of integrated sensitivity is determined under Qingdao port conditions, with r_1=0.3， r_2=0.4， r_3=0.3.

Because of secrecy of these practical accidents, we hide the vessel names. The quantified values are shown in Table 4.1.

Table 4.1- Quantification of oil spills indicators in Qingdao port

Source: Li, G.X. (2005). *2005 Pollution Prevention Cases*. China Shandong MSA.

Lin, B. (2006). *2006 Pollution Prevention Cases.* China Shandong MSA.

Date of oil spills	Oil spill Volume	Integrated sensitivity	Toxicity	Persiste -nce	Flammabi -lity	Damage of ships	Age of ships	DWT	Type	Weather
2005.7.22	0.7	0.1	0.2	0.5	0.5	0.6	0.7	0.5	0.8	0.8
2005.9.14	0.6	0.1	0.9	0.2	0.9	0.1	0.8	0.1	0.1	0.4
2000.6.18	0.5	0.1	2	0.8	0.2	0.1	0.8	0.1	0.1	0.5
2006.9.29	0.2	0.1	0.7	0.2	0.7	0.1	0.7	0.1	0.1	0.3
2006.2.17	0.6	0.1	0.8	0.1	0.8	0.4	0.5	0.2	0.1	0.3
2006.4.17	0.1	0.1	0.9	0.2	0.7	0.2	0.1	0.1	0.1	0.3
2006.11.18	0.1	0.1	0.7	0.1	0.8	0.3	0.5	0.1	0.1	0.2
2006.3.13	0.1	0.1	0.7	0.1	0.7	0.1	0.2	0.1	0.1	0.2
2006.6.5	0.5	0.3	0.9	0.5	0.5	0.1	0.6	0.2	0.7	0.4
2006.9.16	0.3	0.1	0.7	0.2	0.8	0.2	0.6	0.8	0.5	0.4

4.3 Neural network evaluation method examples of accident levels

4.3.1 Determination of the number of input and output layer neurons units

According to above analysis, we set the neural units number of input layer in BP is ten, which represents oil volume, integrated sensitivity, toxicity, persistence, flammability, damage of ships, age of ships, tonnage, type, and weather. And we set the units number of output layer is five, which represents grades of oil spills, general, moderate, relatively serious, serious, and fatal level. Number of neural units in middle layer will be determined during the training process.

4.3.2 Selection of training sample data

We take 21 oil spills as evaluation criteria and use their quantified indicators (see Table 4.2) to train neural network. After training, the network will has good learning ability. Then, we will use the network to test samples.

Table 4.2- Training samples of input

Source: Liu, S.Y. (2005).*Study on Marine Oil Spill Emergency and Decision Making*. Master's Thesis, Shanghai Maritime University, Shanghai, China.

Indicators / No.	Oil spill Volume	Integrated sensitivity	Toxicity	Persiste -nce	Flamma -bility	Damage of ships	Age of ships	DWT	Type	Weather
1	0.74	0.14	0.9	0.1	0.9	0.1	0.4	0.2	0.7	0.8
2	0.95	0.32	0.2	0.7	0.2	0.2	0.5	0.3	0.7	0.1
3	0.67	0.60	0.7	0.3	0.8	0.1	0.3	0.1	0.1	0.5
4	0.67	0.30	0.7	0.3	0.8	0.1	0.2	0.4	0.7	0.1
5	0.45	0.26	0.7	0.3	0.8	0.1	0.6	0.4	0.7	0.5
6	1	0.64	0.6	0.9	0.3	0.7	0.7	0.8	0.9	0.2
7	0.63	0.10	0.2	0.9	0.2	0.2	0.5	0.9	0.7	0.1
8	1	0.36	0.1	0.9	0.1	0.6	0.3	0.8	0.9	0.4
9	0.62	0.32	0.7	0.3	0.8	0.8	0.6	0.6	0.2	0.4
10	0.74	0.14	0.2	0.9	0.3	0.3	0.2	0.4	0.8	0.1
11	0.24	0.1	0.1	0.9	0.1	0.1	0.2	1	0.1	0.5
12	0.62	0.12	0.2	0.9	0.3	0.6	0.5	0.3	0.6	0.9

13	1	0.26	0.2	0.9	0.3	0.6	0.8	1	1	0.4
14	0.62	0.14	1	0.1	1	0.1	0.2	0.8	0.7	0.4
15	1	0.36	1	0.1	1	0.5	0.4	0.5	0.5	0.1
16	1	0.12	0.6	0.9	0.3	0.7	0.8	0.7	0.1	0.3
17	0.63	0.10	0.6	0.7	0.7	0.1	0.2	0.2	0.7	0.9
18	0.31	0.1	0.6	0.7	0.7	0.3	0.5	0.2	0.5	0.1
19	0.83	1	0.6	0.7	0.7	0.4	0.5	0.8	0.2	0.6
20	0.45	0.98	0.4	0.5	0.2	0.1	0.3	0.2	0.5	0.7
21	1	0.14	0.2	0.9	0.3	0.9	0.7	0.5	0.5	0.6

And, according to the criteria of evaluating accident levels, we evaluate the 21 oil spills' levels. (See Table 4.3)

Table 4.3- Evaluation of oil spills' levels

Source: Liu, S.Y. (2005).*Study on Marine Oil Spill Emergency and Decision Making*. Master's Thesis, Shanghai Maritime University, Shanghai, China.

No.	General Accident	Moderate Accident	Relatively serious Accident	Serious Accident	Fatal Accident
1	0	0	0.15	0.8	0.05
2	0	0.05	0.05	0.9	0
3	0	0	0.4	0.6	0
4	0	0.1	0.8	0.1	0
5	0.1	0.7	0.2	0	0
6	0	0	0	0.05	0.95
7	0	0.3	0.7	0	0
8	0	0	0.05	0.10	0.85
9	0	0	0.9	0.1	0
10	0	0.15	0.85	0	0
11	0.9	0.10	0	0	0
12	0	0.05	0.75	0.20	0
13	0	0	0	0	1
14	0	0	0.95	0.05	0
15	0	0	0	0	1
16	0	0	0	0.05	0.95
17	0	0	0.70	0.30	0
18	0.85	0.1	0.05	0	0

19	0	0	0	0.3	0.7
20	0	0.2	0.3	0.5	0
21	0	0	0	0	1

4.3.3 Analysis of neural network training

1. Number of neural units in hidden layer is 10, network training time is 3'33, and the outcome is shown in Figure 4.4.

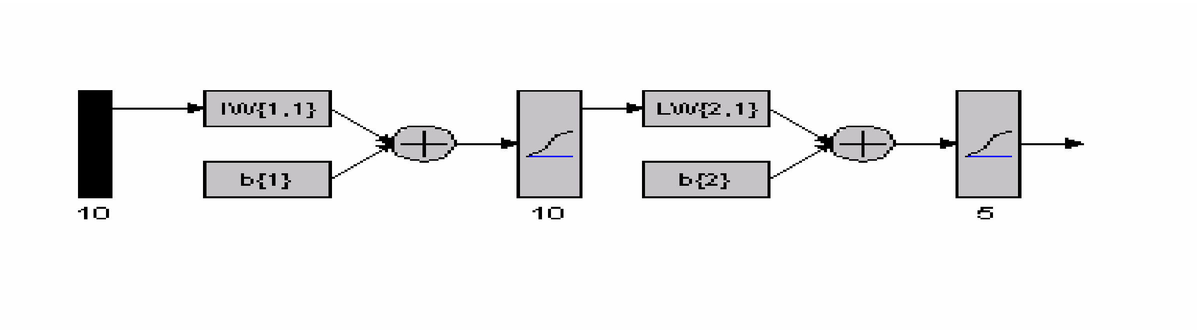

Figure 4.3- Network with 10 units in hidden layer

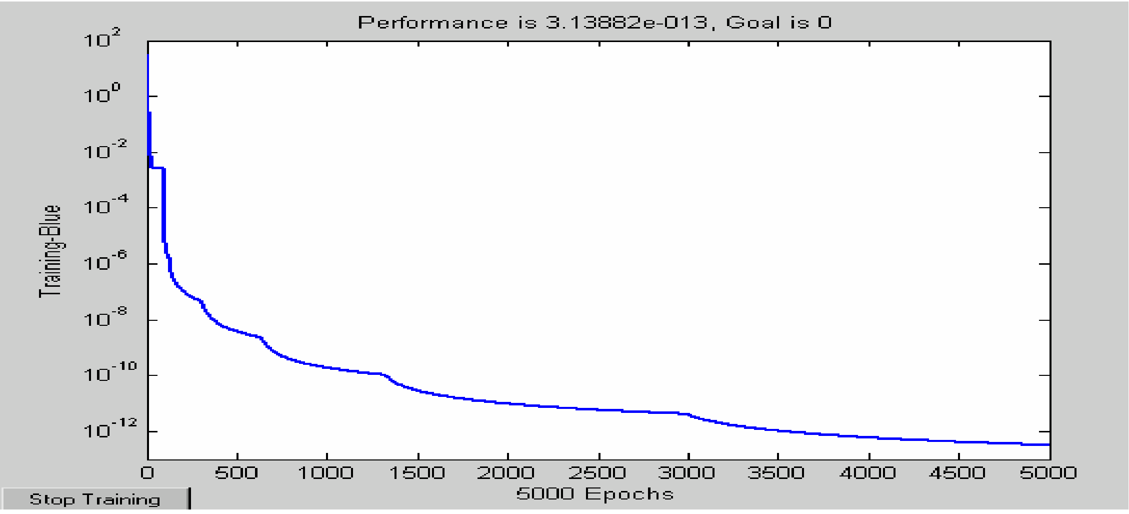

Figure 4.4- Training Blue with 5000 epochs

Input the test samples into the trained network, the output is shown in Table 4.4.

Table 4.4- Output of 10 units in hidden layer and Consistency test

General Accident	Moderate Accident	Relatively serious Accident	Serious Accident	Fatal Accident	Network Judgment	Actual Level	Consistency
0	0.24611	0.2018	0.0018448	0.8262	F	F	Y
0.043406	0	0	0	0.82017	F	M	N
0.43889	0	0	0	0.063925	G	M	N
0.96774	0.32685	0.78873	0	0	G	G	Y
0	0.00013628	0.99913	0.00043379	0	R	R	Y
0.00044446	0	0.64575	0.26405	0	R	G	N
0.84967	0.020604	0.80254	0	0	G	G	Y
0.029803	0	0.59019	0.00012757	0	R	G	N
0.0026559	0.0061756	0	0	0	M	M	Y
0.90921	0.58507	0.66469	0	0	G	G	Y

2. Number of neural units in hidden layer is 20, network training time is 6’25, and the outcome is shown in Figure 4.6.

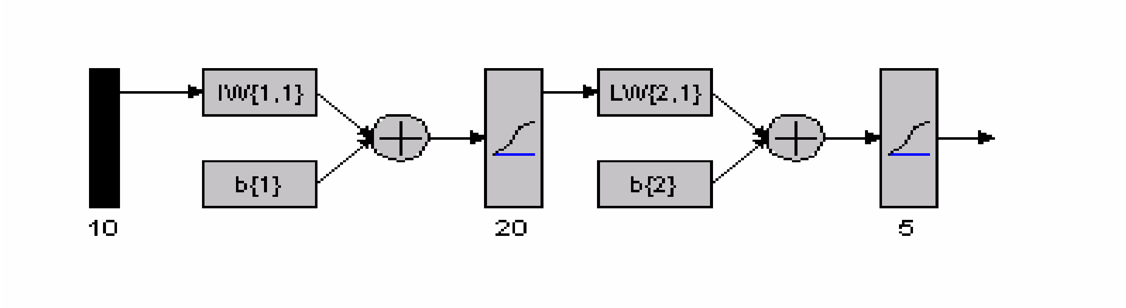

Figure 4.5- Network with 20 units in hidden layer

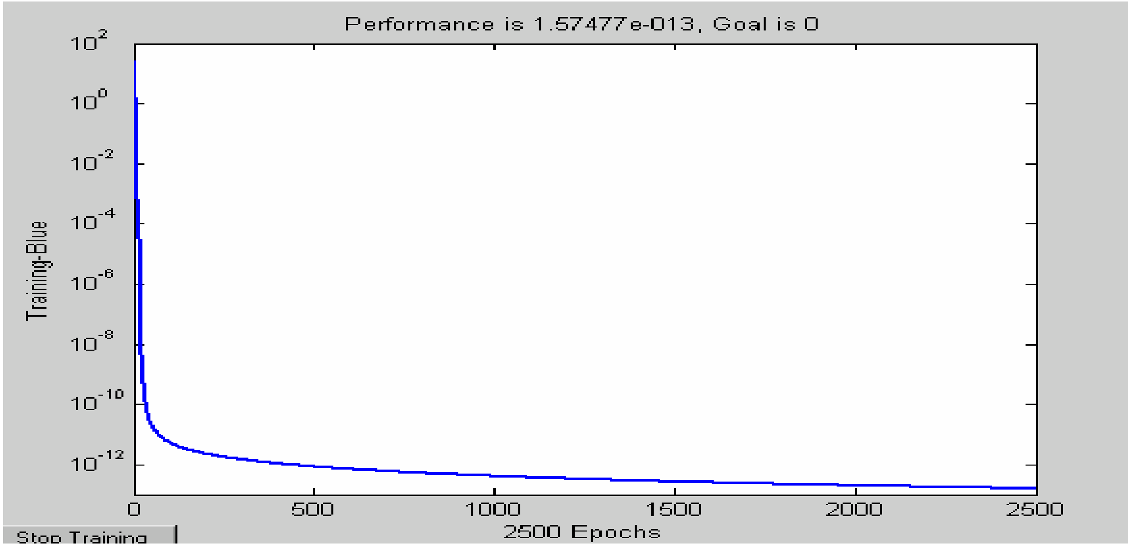

Figure 4.6- Training Blue with 2500 epochs

Input the test samples into the trained network, the output is shown in Table 4.5.

Table 4.5- Output of 20 units in hidden layer and Consistency test

General Accident	Moderate Accident	Relatively serious Accident	Serious Accident	Fatal Accident	Network Judgment	Actual Level	Consistency
0	0.00061447	0.0059595	0.00047191	0.37182	F	F	Y
0.60416	0.000477706	0.0074542	0.00078271	0	G	M	N
0.33047	0	0.036594	0.18792	0	G	M	N
0.99931	0.085772	0.0083475	0	0	G	G	Y
0	0	0.95999	0.89662	0	R	R	Y
0.92865	0.0068373	0.073178	0	0	G	G	Y
0.9991	0.81676	0.16317	0	0	G	G	Y
0.98601	0.68953	0.060996	0	0	G	G	Y
0.0016315	0.42589	0.95492	0.00052402	0	R	M	N
0.91415	0.16081	0.097053	0	0	G	G	Y

3. Number of neural units in hidden layer is 50, network training time is 27’16, and the outcome is shown in Figure 4.8.

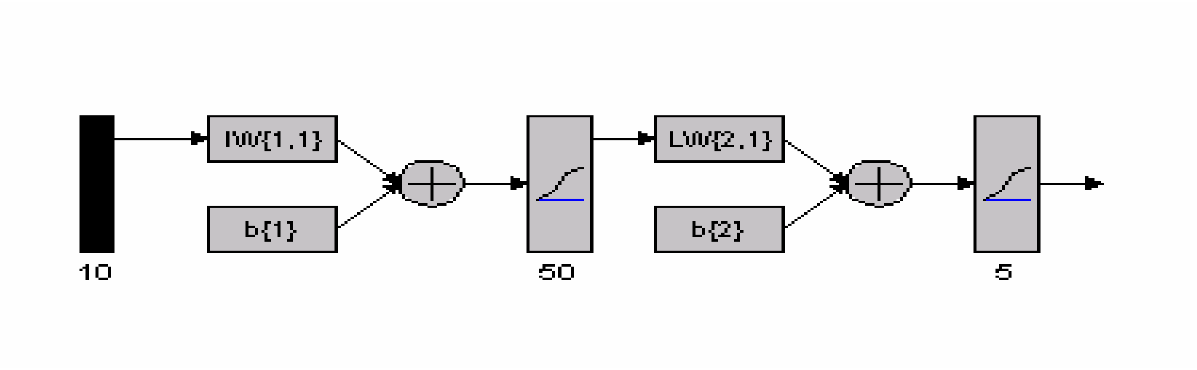

Figure 4.7- Network with 50 units in hidden layer

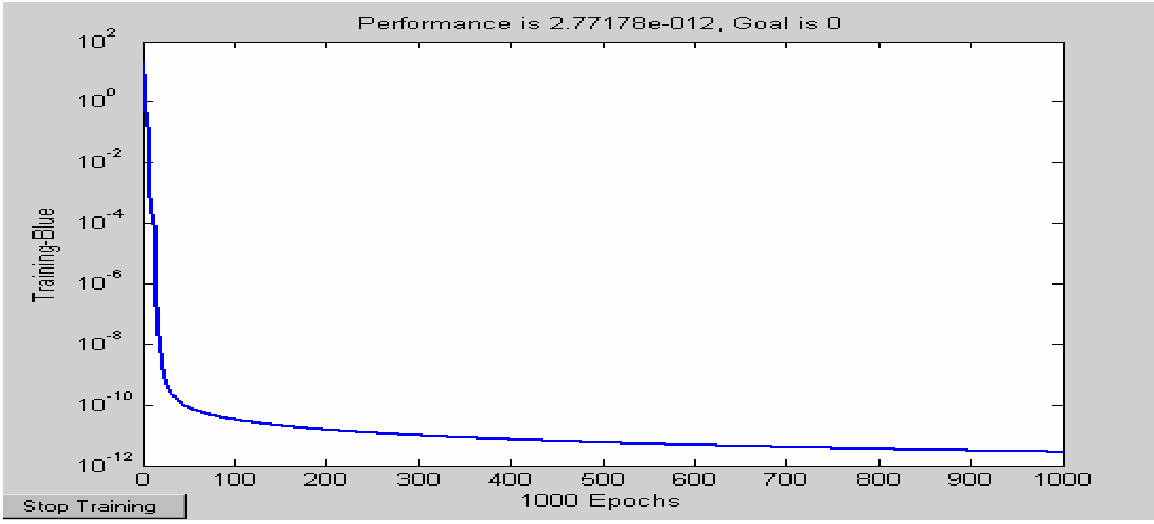

Figure 4.8- Training Blue with 1000 epochs

Input the test samples into the trained network, the output is shown in Table 4.6.

Table 4.6- Output of 50 units in hidden layer and Consistency test

General Accident	Moderate Accident	Relatively serious Accident	Serious Accident	Fatal Accident	Network Judgment	Actual Level	Consistency
0	0.00061431	0.14331	0.00034436	0.0086127	R	F	N
0.084564	0.64255	0.0030423	0.00022659	0	M	M	Y
0.31522	0.00050993	0	0.11384	0	G	M	N
0.99972	0.97862	0.0038918	0	0	G	G	Y
0.0014118	0.0005327	0.68928	0.00031092	0	R	R	Y
0.10114	0.0013679	0.9901	0.014841	0	R	G	N
0.99202	0.079122	0.039938	0	0	G	G	Y
0.66282	0.033999	0.5626	0.00091371	0	G	G	Y
0.0092186	0.95424	0.16602	0.001024	0	M	M	Y
0.46321	0.0051722	0.46283	0	0	G	G	Y

4.3.4 Analysis of output

We train neural networks by gradually increasing the number of neural units in hidden layer, and take the accuracy of network judgment and calculation speed as the main indicators. The comparison of output is shown in Table 4.7.

Table 4.7- Comparison of output in 3 groups

No. of Neural Units	10	20	50
Training Time	3'33	6'25	27'16
Accuracy	60%	70%	70%

Clearly, when unit number is 20, the judgment to test samples by trained networks is the most accurate, and calculation speed is fastest. By comparison, if we reduce the unit number, calculation speed is fast, but accuracy reduces. And if we increase the unit number, accuracy is the same with the second output, and the calculation speed is too slow. Therefore, number of neural units in hidden layer is 20 is our best choice. When oil spills happen, we can input the 10 quantified indicators, and select neural units 20. The software will judge oil spill grades the most effectively.

5. Establishment of oil spill emergency response system in Qingdao port

All the oil spill emergency response systems are made up these parts shown in Figure 5.1. As Chapter 3 has mentioned, the system we will establish in Qingdao port is the third level oil spill emergency response system, whose contingency plan is below national, and sea regional, but above ship contingency plan.

Oil spill emergency response software, as the key of emergency response, has got the solution in Chapter 4. With the accurate judgment of oil spill grades, emergency response can operate smoothly in the gradually improving emergency response system. In this chapter, we will take the oil spill grade judgment as scientific evidences to make graded responses in the process of establishing oil spill emergency response system.

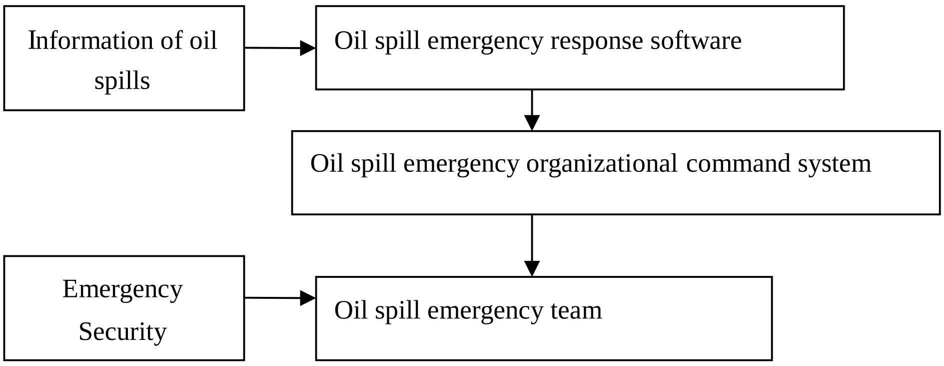

Figure 5.1- Framework of oil spill emergency response system

Source: Shi, Y.Q., Chen, L. (2003). Research on the Frame of Oil Spill Emergency Response System at Sea. *Marine Environmental Science, 22 (2), 40-43*.

5.1 Establishment of contingency plan

Contingency plan is the important component of emergency response, and it can be classified into different levels according to the response levels. But, for all level plans, their core content is about Report and Activity, which means graded report system and emergency activity ways. Contingency plans should clearly stipulate the specific contents of the report, the report targets and reporting ways. According to the responsibilities of agencies or organizations implementing contingency plans, different level contingency plans should stipulate the specific emergency activity ways of plan actors.

Generally, a comprehensive contingency plan includes following parts, general principles; organization command, outline of responsibilities and instruction of restrictions; oil spill prediction, sensitive regions and protective principles; staff, materials, resources, and traffic of oil spill emergency response; emergency response center and its responsibilities; emergency response procedure; oil spill emergency response technology; disposal of oil of recovery and waste contaminating oil; information release; communication links; regional cooperation and joint of plans among ports; training, drilling and modification of plan.

5.2 The establishment of oil spill emergency organizational command system in Qingdao port

First all, we should confirm the positions of the members related to oil spill emergency response. Then we can build up a command system.

The commander of emergency response command in Qingdao port is the vice mayor of Qingdao government who is in charge of related affairs. Executive deputy commander is taken charge by director general of Qingdao MSA. Deputy Commanders are taken charge by deputy secretary-general of Qingdao government, director general of Qingdao AWS, deputy director of Qingdao Transportation Committee, director general of Qingdao AOF, office director of NSF.

Command office will be set in Qingdao MSA, and the chief will be taken charged by director general of Qingdao MSA, deputy chief as deputy director general of Qingdao MSA who is in charge of marine pollutions from ships.

Experts group will be made up of professionals on environmental protection, maritime affairs, oil spill removal, chemicals safety and rescue, shipping, salvage, marine, meteorology, fisheries, ecology, health, fire, tourism, communications, law, and insurances. Members of experts group will be recommended by the related departments, and hired by command office.

Ship pollution emergency response forces include national official forces, such as the professional agencies set by China government, ship pollution emergency agencies, and emergency forces of related authorities; local official forces from Qingdao government; forces of army and police; other social forces from enterprises, social organizations and individuals.

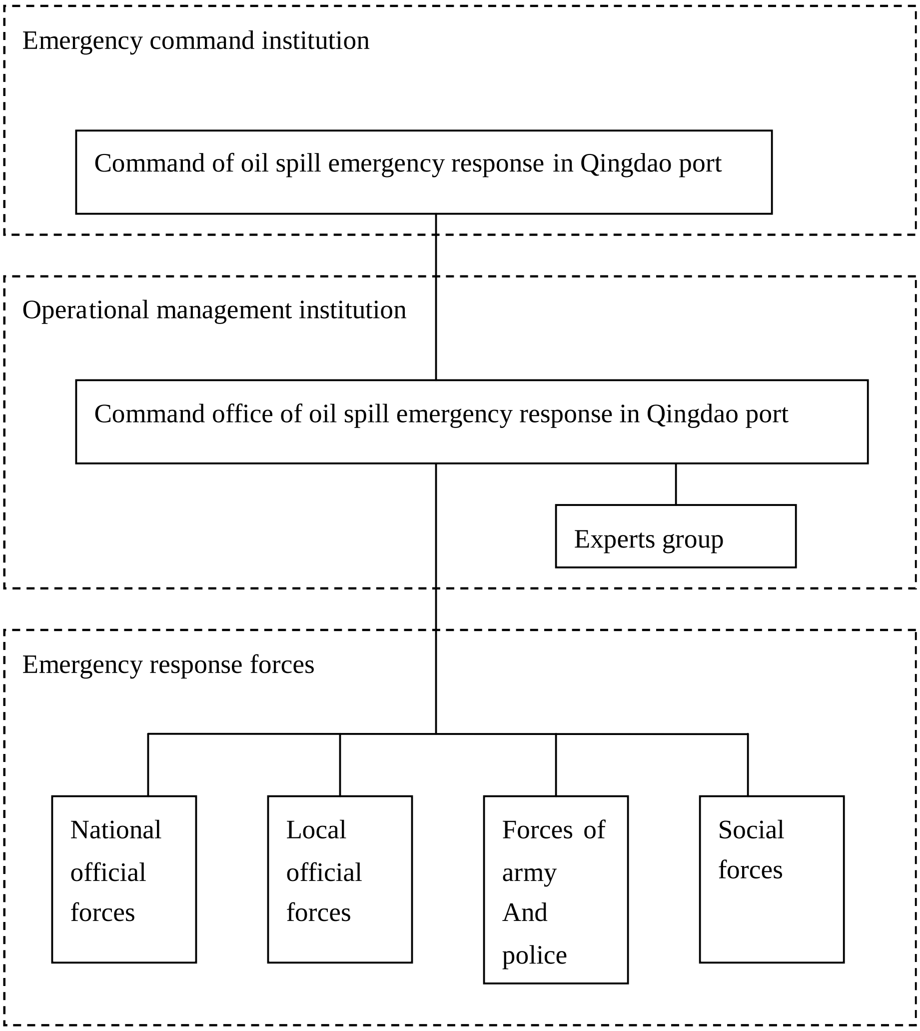

Figure 5.2- Framework of emergency organizational command system
Source: Qingdao MSA. (2005). *Qingdao Marine Pollution Emergency Plan*. Qingdao Government, Qingdao, China.

5.3 Graded oil spill emergency response measures in Qingdao port

Graded response measures in the oil spill emergency response system, can rationalized the whole operational process of system. According to different levels of oil spills, we can transfer relative equipments and personnel in different levels. This manner not only saves staff and material, but also increases the efficiency of operations. We divide the emergency response measures into three levels, moderate accident is 3rd level, relatively serious accident is 2nd level, and serious accident is 1st level. Response measure in all levels will be directed and operated by oil spill emergency response command in Qingdao port. For general accident and fatal accident, the command will start other level contingency plans.

We have drawn out the flowchart of graded emergency response measures. (See Figure 5.3) In each level, we will mobilize different forces and take different measures to operate different graded oil spills.

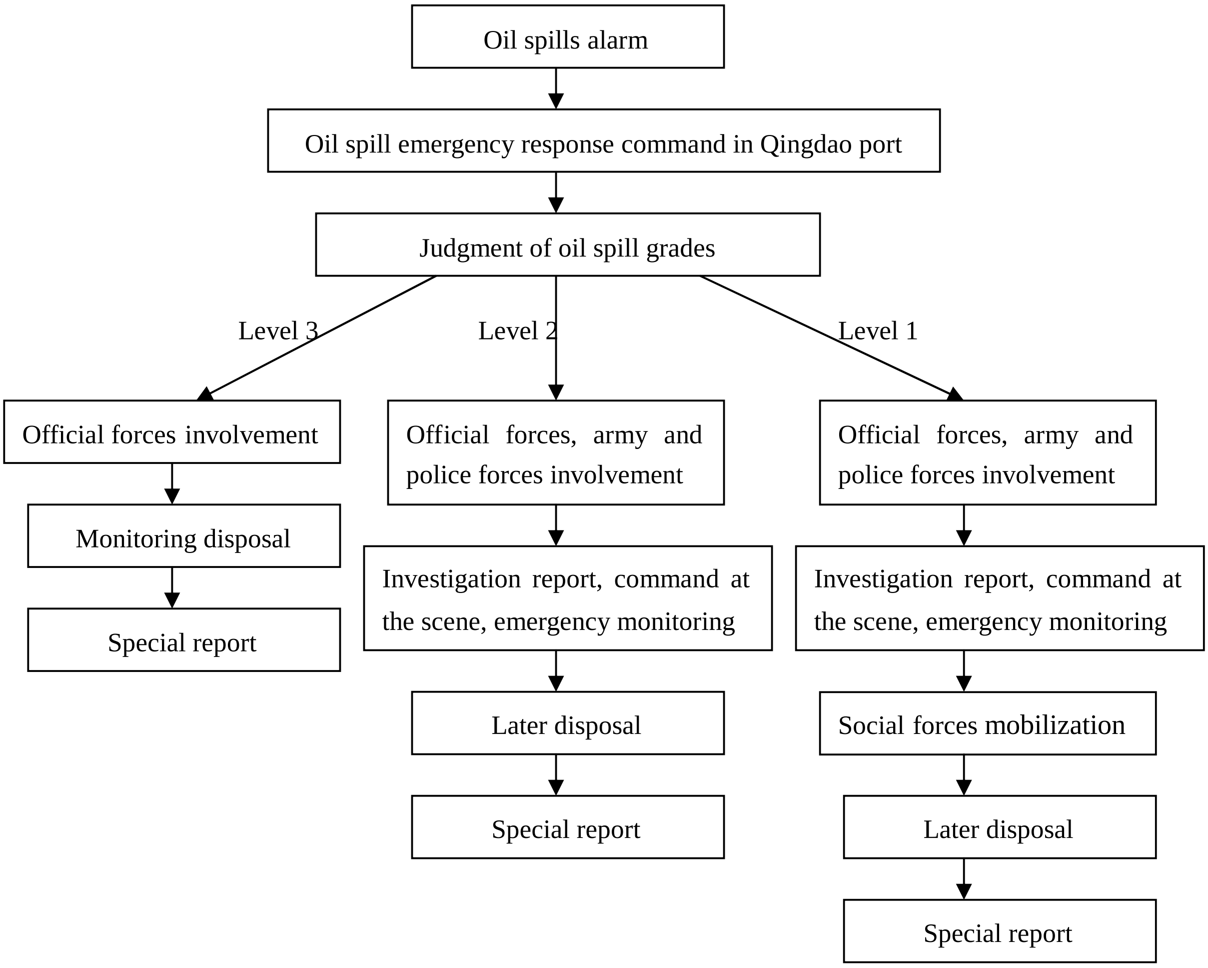

Figure 5.3 –Flowchart of graded emergency response measures in Qingdao port

5.3.1 Response technical measure in Level 3

After receiving the alarm, the command of oil spill emergency response system in Qingdao port will collect accident information and evaluate the grades of oil spills. Then, the command will give the proper removal project.

Technically, if there are effects of wind and waves, oil spills may spread to sensitive regions. So, we should use some amount of barriers in the direction of sensitive sea areas. If the oil spill area is large, we should insufflate dispersants. If the oil spill layer gets to some thickness, and spilled time is not very long, we can use some fire-resistance booms and burn spill oil at the scene with timely monitoring.

If the sea condition is good, for relatively large oil spill volume as liquid, we can first use barriers to restrict the spread of oil, and use recovery equipments. The solid spilled oil recovery can use oil trawls. When facing small amount of oil spills, liquid spilled oil can either use skimmers and recovery equipments, or sorbent materials. And solid oil can be operated by small oil trawls.

5.3.2 Response technical measure in Level 2

When ships happen relatively seriously oil spills, and pollute relatively large areas of ocean environment. The emergency forces and resources of port, quay and ships will be insufficient to control accidents, and we need reinforcements of army and police.

Technically, Qingdao port is fit for fence booms, which are usually used in harbor or semi-open sea area. The fence booms can be easily operated and stay at sea for long time, which can save financial cost. And the effect of standing against wind is very good.

5.3.3 Response technical measure in Level 1

Once there happen fatal oil spills from ships, the ocean environment will be seriously polluted, and cause a great deal of losses in economic. Because of the insufficient emergency resources, it will be hard to control the accident by port, quay, ship emergency forces and reinforcements of army and police, we need to mobilize all the social forces to involve in the operations.

Technically, for serious oil spills, wind and waves will definitely affect the oil recovery. We should select equipments which can defend inclement weather. We can choose British or Danish inflatable booms, which can defend gale and working efficiency is very high.

We should also select the operational methods according to oil characteristics. If oil type is light oil, we can use sorbent materials and recovery equipments in dealing with residual oil, or let it naturally volatile. While, for heavy oil, we should use gelling agents, and use net skimmers for recovery, then use sorbent materials to deal with the residual oil.

5.3.4 Emergency measures of other graded oil spills

General oil spills mainly depend on ship forces under ship oil spill contingency plan, and related departments of Qingdao port will report and record. After receiving the alarm, the command will judge the grade of oil spills by oil spill emergency response software, and confirm the fatal level of the accident. Then, the command will immediately report to the higher level to start North Regional Oil Spill Contingency Plan. The provincial government will take charge of command, and Qingdao port should try its best to cooperate during the operation.

5.4 Security of oil spill emergency response system in Qingdao port

5.4.1 Establishment of professional decontamination forces in oil spill emergency response

Emergency team is the forces which are specially responsible for the polluted accident scenes. The team should include certain size and quantity of pollution clean-up devices, equipments and well-trained operators. When establishing the emergency team in Qingdao port, we should put emphasis on the facets as follows, emergency forces of enterprises, national assault forces, establishment of professional remediation companies, promotion of regional corporation anti-pollution mechanism, increasing abilities of oil spill emergency response, and establishment of experts groups.

5.4.2 Establishment of emergency security

1. Emergency equipment security

Qingdao government can build up oil spill emergency response base according to local marine pollution risk investment. The base, as the professional oil spill emergency forces, will provide security to local marine pollution emergency response, and can also support provincial and regional oil spill emergency response.

Port, quay, and station should equip related pollution emergency devices under the national laws, regulations and standards. Related enterprises should equip essential devices for oil spill emergency response under the regulations.

The oil spill emergency devices or resources of other enterprises or departments should be recorded in the registration by marine management agencies, as social forces of oil spill emergency response.

Command office should establish database of popedom marine pollution emergency equipment resources.

2. Emergency team security

Marine pollution emergency team is made up of professional and other emergency teams.

Command office takes charge of establishing government professional marine pollution emergency response team, and strengthening the forces on basis of existing staff and devices, to increase the ability to deal with large scale marine pollution.

Other emergency team includes non-government emergency organizations, professional remediation groups under market-oriented operation, and remediation forces of enterprises. It is good for Qingdao port to encouraging joint and private enterprises to invest on establishing professional remediation teams. We can establish emergency team of Qingdao port by achieving diversified, according to the laws of market.

Command office is responsible for establishing the database of marine pollution emergency teams.

In addition, the establishment of emergency security also includes the building of health security, material and transportation security, finance security, social mobilization security, emergency shelter security, and technical reserves and security.

As a whole, during the process of establishing oil spill emergency response system in Qingdao port, we should consider in the overall. Although we have solved oil spill grade judgment, which is the most important part in establishment of oil spill emergency response system, we should still consider many facets, the contingency plan, emergency response command, emergency response measures and their specific implementations, and the emergency security. All these parts are indispensable.

6. Conclusion

In 1960s, under the condition that the whole world paid great attention to oil spills, ports of developed countries established completed oil spill emergency response systems, and the systems operated well in dealing with oil spills. By comparison, establishments of port oil spill emergency response systems in China are relatively weak.

Qingdao port is the biggest port of crude oil throughput in China mainland. Rapid and steady development of oil transportation not only brings the huge economical benefits, but also brings potential oil spill risks. Moreover, the emergency response in Qingdao port is relatively weak, and has some problems. Therefore, establishing oil spill emergency response system in Qingdao port is very meaningful.

During the whole process of oil spill emergency response, oil spill grade judgment plays an essential role. Oil spill grade judgment doesn't only affect the selection of oil spill operations, but also decides the scale and direction of emergency response activities. Only according to the accurate judgment of oil spill grades, we can establish a normally operational oil spill emergency response system. In the proper thesis, we mainly enclose the judgment of oil spill grades, determine emergency response measures on different levels, transfers of related cleanup equipments and staff, and finish the establishment of oil spill emergency response system in Qingdao port.

The establishment of this system provides security for the development of Qingdao port, helps maintain the health of ocean environment, and meanwhile, ensures the good operational environment of Qingdao port. The proper thesis supplements some researches on oil spill emergency response in Qingdao port. We hope it can provide some useful reference to study of port oil spill emergency response in China.

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The China Qingdao AWS website gives further information on courses
(http://www.qdajj.gov.cn/)

The China Qingdao port website gives further information on courses
(http://www.qdport.com/)

The China Shandong MSA website gives further information on courses
(http://www.sdmsa.gov.cn/)

The State Environmental Protection Administration of China website gives further information on courses
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Appendix: MATLAB Program

```
P=[0.74 0.95 0.67 0.67 0.45 1 0.63 1 0.62 0.74 0.24 0.62 1 0.62 1 1 0.63 0.31 0.83 
0.45 1;
   0.14 0.32 0.60 0.30 0.26 0.64 0.10 0.36 0.32 0.14 0.1 0.12 0.26 0.14 0.36 0.12 
0.10 0.1 1 0.98 0.14;
   0.9 0.2 0.7 0.7 0.7 0.6 0.2 0.1 0.7 0.2 0.1 0.2 0.2 1 1 0.6 0.6 0.6 0.6 0.4 0.2;
   0.1 0.7 0.3 0.3 0.3 0.9 0.9 0.9 0.3 0.9 0.9 0.9 0.9 0.1 0.1 0.9 0.7 0.7 0.7 0.5 0.9;
   0.9 0.2 0.8 0.8 0.8 0.3 0.2 0.1 0.8 0.3 0.1 0.3 0.3 1 1 0.3 0.7 0.7 0.7 0.2 0.3;
   0.1 0.2 0.1 0.1 0.1 0.7 0.2 0.6 0.8 0.3 0.1 0.6 0.6 0.1 0.5 0.7 0.1 0.3 0.4 0.1 0.9;
   0.4 0.5 0.3 0.2 0.6 0.7 0.5 0.3 0.6 0.2 0.2 0.5 0.8 0.2 0.4 0.8 0.2 0.5 0.5 0.3 0.7;
   0.2 0.3 0.1 0.4 0.4 0.8 0.9 0.8 0.6 0.4 1 0.3 1 0.8 0.5 0.7 0.2 0.2 0.8 0.2 0.5;
   0.7 0.7 0.1 0.7 0.7 0.9 0.7 0.9 0.2 0.8 0.1 0.6 1 0.7 0.5 0.1 0.7 0.5 0.2 0.5 0.5;
   0.8 0.1 0.5 0.1 0.5 0.2 0.1 0.4 0.4 0.1 0.5 0.9 0.4 0.4 0.1 0.3 0.9 0.1 0.6 0.7 0.6]
T=[0 0 0 0 0.1 0 0 0 0 0 0.9 0 0 0 0 0 0 0.85 0 0 0;
   0 0.05 0 0.1 0.7 0 0.3 0 0 0.15 0.10 0.05 0 0 0 0 0 0.1 0 0.2 0;
   0.15 0.05 0.4 0.8 0.2 0 0.7 0.05 0.9 0.85 0 0.75 0 0.95 0 0 0.7 0.05 0 0.3 0;
   0.8 0.9 0.6 0.1 0 0.05 0 0.10 0.1 0 0 0.2 0 0.05 0 0.05 0.3 0 0.3 0.5 0;
   0.05 0 0 0 0 0.95 0 0.85 0 0 0 0 1 0 1 0.95 0 0 0.7 0 1]
[R,Q]=size(P);
[S2,Q]=size(T);
S1=10;
[W1,B1]=nwlog(S1,R);
[W2,B2]=rands(S2,S1);
W2=W2*0.5;
B2=B2*0.5;
```

```
disp_freq=100;max_epochs=5000;err_goal=0.01;lr=0.1;lr_inc=1.05;lr_dec=0.7;mom
_const=0.95;
err_ratio=1.04;
TP=[disp_freq max_epochs err_goal lr lr_inc lr_dec mom_const err_ratio];
[W1,B1,W2,B2,epochs,TE]=trainbpx(W1,B1,'logsig',W2,B2,'logsig',P,T,TP);
```