The Capabilities for Prevention and Control of Marine Pollution by Ships: China’s Construction Experiences and Future Perspectives

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Abstract. The transportation of crude oil will still mainly be based on tanker in the next few decades. Although the number of large-scale marine oil spill has decreased significantly over the last half a century, our world will continuously confront many challenges about PCMPS (prevention and control of marine pollution by ships) inevitably. China has made great achievements in the capabilities for prevention and control of marine pollution by ships in the past decade, which mainly includes top-level design of framework, laws and regulations, industrial policies, technical specifications, spill emergency response team, contingency plan, etc. Moreover, with actively integrated of the emergency materials invested by governments, ship pollution removal enterprises and port enterprises, an emergency response system for PCMPS has been initially formed. Meanwhile, China needs continuous improvement in many aspects for marine environmental challenges in the future, such as the soft power of warehouses, coordination mechanism of all emergency forces, technical standard system, daily management and maintenance fund, waste receiving capacity, monitoring of oil spill site, etc.

1. Introduction
In 2018, the crude oil imports of China’s reached 461.9 million tons, and with an external dependence of 70.9% [1]. The total number of ports with throughput more than 100 million tons reached 36, and the number of berths over 10 thousand tons was about 2,300 in China [2]. The world's top 20 large of throughput ports and container ports, China accounts for 12 and 9 respectively [3].

Now, about two thirds of the crude oil and its products is transported by ships in the world [4]. Oil tanker is basically more than 100,000 tons [5,6]. As at 24 December 2018, COSCO Shipping Energy (China) owned 160 oil tankers with a total shipping capacity of 22.54 million DWT (Deadweight Tonnage) and ranked first globally. COSCO Shipping Energy also held an order of 16 oil tankers with a total shipping capacity of 3.4 million DWT [7].

Some developed countries already have established relatively complete oil spill prevention and emergency system since 1970s[8-16]. Over the last half century, the number of large spills (more than 700 tonnes) has decreased significantly, and since 2010 averages 1.9 per year in the world[17]. But the oil spill accident cannot be completely avoided, the total oil spill in 2018 was approximately 116,000 tonnes in the world, the majority oil spill involving the accident of SANCHI occurred in the sea near
China [17]. So, it is necessary to continuously improve the prevention and control capabilities for largescale oil spill, although many governments already have made great achievements.

In the past ten years, China has vigorously promoted the construction of capabilities for PCMPS issued a series of laws and regulations, built a number of national oil spill emergency equipment warehouses, approved a large number of ship pollution removal units, and comprehensively launched port enterprises marine pollution assessment. China has basically completed six-level oil spill emergency response system: national, sea area, province, port and ship, which enabled China to have overall safeguard mechanism in response to largescale marine pollution accidents[6]. The main goal of the capabilities for prevention and control oil spill is marine pollution by ships, and taking into account the offshore drilling platform, undersea pipeline ,etc.

On January 6, 2018, the tanker SANCHI continued to burn and explode due to a collision accident, then sank after 8 days, a large number of condensates leaked. Chinese government launched a largescale oil spill contingency plan, and invested a large number of maritime law enforcement vessels, professional oil spill dispose vessels and other emergency materials[18,19]. This accident did not cause serious environmental pollution.

This contribution introduces China's achievement of the PCMPS in the past few years. The mainly contents include: overall design framework, laws and regulations, technical specifications, oil spill emergency equipment warehouse, ship pollution accident damage compensation mechanism, oil spill emergency drills, etc. Finally, The further improvement of China's PCMPS is discussed.

2. Overall framework of the capabilities for PCMPS in China

2.1. General principle
The general principle of the China's PCMPS capabilities construction: overall leadership of the central government, management responsibility resides at local governments, port enterprises assume main body responsibility, and encourage other social forces to participate [20].

IMO Manual on Oil Spill Risk Evaluation and Assessment of Response Preparedness(2010) divided oil spill response into five parts: laws and regulations, contingency plans, emergency equipment, and training and drills[21].

2.2. The criterion of national largescale marine oil spill accident
MMMSR (The Inter-Ministerial Joint Meeting of the National Largescale Marine Oil Spill Response) have decided to set up NMOCP (National Largescale Marine Oil Spill Contingency Plan of China) in march 2018. According to the contingency disposal plan, national large marine oil spill can be confirmed by one of the following: (1) The oil spill exceeds 500 tons, and the contaminated water locates in sensitive area. (2) It may cause significant international impact or a major social impact. (3) The oil spill exceeds 1000 tons[22].

2.3. MSCBP (National Largescale Marine Oil Spill Response capabilities Building Plan) (2015-2020)
MSCBP (2015-2020) is the top-level design of China's capabilities construction of marine oil spill emergency response in recent years. The key elements are as follows[22]:

(1) MSCBP (2015-2020) unified considers four types of risk sources: oil platforms, ships, submarine pipelines and coastal storage tanks.

(2) MSCBP (2015-2020) puts forward specific quantitative targets are as follows: First, the emergency monitoring system cover the waters under Chinese jurisdiction, and the marine oil spill emergency materials focus on the seas 50 nautical miles from the shore. Second, the marine oil spill emergency materials can be dispatched under the 5th sea state. Emergency response operations can be carried out under the 4th sea state. Third, the first batch of air surveillance forces and marine oil spill emergency materials can reach the accident sea area 50 nautical miles from the shore within 2 hours and 6 hours respectively. Fourth, the marine oil spill response capabilities can confront 1,000 tons
within 50 nautical miles from the shore, and the high risk sea area should confront 10,000 tons. Fifth, the oil spill coastal removal capabilities of coastal provinces should reach 10,000 tons respectively.

3) Based on the combination of hard power and soft power, MSCBP (2015-2020) proposed the construction tasks of emergency organization, surveillance and monitoring capabilities, emergency team, etc.

4) Based on the existing emergency information system and database, an unimpeded marine oil spill emergency communication system will be built in the next several years, which linking marine oil spill emergency center of central government and the relevant provincial government, and more than 20 member units of MMMSR. Then an oil spill emergency organization and command system is unified, and information resources can sharing in real time.

5) Improving the accuracy and coverage of oil spill monitoring by a variety of integrated technologies such as aerospace remote sensing, monitoring buoys, shore-based radar and ship-borne radar, etc, which will promote the national coastal oil spill monitoring and drift warning capabilities.

6) According to MSCBP (2015-2020), China will build 191 equipment warehouses and 260 emergency disposal vessels in 44 cities along the coastal areas. After integrated the existing emergency forces, a professional marine oil spill emergency disposal team will formed, which composed of national teams, enterprise teams and volunteer teams, etc.

2.4. Organization
Combines the member units function of MMMSR, NMOCP 2018 clearly divide the responsibilities of member units, and define the organization system as well as the work contents for emergency response.

2.4.1. Main organizer. After the oil spill emergency response was initiated, MMMSR is responsible for organizing and guiding the national largescale oil spill emergency response [23,24].

2.4.2. CMOSR (China Marine Oil Spill Response Center). CMOSR is the daily office of the MMMSR, and is responsible for communication with member units and local governments, implementing directive of MMMSR, carrying out the coordination of the national largescale marine oil spill emergency organization. In daily work, CMOSR formulates and organizes the training and drilling regularly, etc.

2.4.3. Joint Headquarters. MMMSR can establish a joint command department according to the needs of emergency response, and be responsible for the coordination and command of the inter-ministerial level. If necessary, the Joint Headquarters can send an working group to assist the on-site headquarters for emergency response.

2.4.4. On-site Headquarters. After the emergency response was initiated, the provincial government and relevant units should set up an On-site Headquarters for the on-site emergency disposal.

2.4.5. Related departments and units. In accordance with the requirements of NMOCP 2018, relevant administrative departments and enterprises should coordinate emergency forces within their duties, such as verify and assess the oil spill, take reasonable emergency measures in the first time, promptly notify CMOSR and other relevant units, etc.

2.4.6. Experts Panel. MMMSR already establish a Experts Panel of national largescale marine oil spill emergency response, which is recommended by the member units of MMMSR. National largescale emergency response process of China is presented in Figure 1.
3. International conventions, laws and technical specifications

3.1. International conventions
As a class A member state of IMO, China actively participates in relevant conventions. Some of the conventions are as follows:

(1) International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), and all its annexes, and several amendments applied to China since 2005.

(2) International Convention on Civil Liability for Bunker Oil Pollution Damage (2001), applied to China on 9 March 2009.

(3) International Convention on Oil pollution Preparedness, Response and Co-operation (1990), applied to China on 20 March 1998.

(4) International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC code 2004), the earlier versions applied to China on 1 July 1986.

(5) International Maritime Organization Protocol of 1992 to Amend the International Convention on Civil Liability for Oil Pollution Damage of 29 November 1969.

(6) International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code), applied to China on 1 July 1998.

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3.2. Laws and regulations
In recent years, China has intensively introduced a number of laws, regulations and technical specifications for the PCMPS, as shown in Table 1 [25].

| Num | Name of Law                                                                                           | Remarks                        |
|-----|--------------------------------------------------------------------------------------------------------|--------------------------------|
| 1   | Marine Environmental Protection Law of the People's Republic of China                                 | Took affect in 2000 , revised in 2017 |
| 2   | The Regulations of People's Republic of China on Administration of the Prevention and Control of Marine Environment Pollution from Ships | Took affect in 2010 , revised in 2013, |
3.3. Technical Specifications

The technical specifications related to the prevention and control of marine oil spills mainly are national standards (GB), industry standards (marine engineering industry standards (HY), transportation industry standards (JT), etc.), as shown in Table 2[25].

| Num | Standard Number | Name of Standard                                                                 |
|-----|-----------------|-----------------------------------------------------------------------------------|
| 1   | JT/T877-2013    | Guidelines on the Assessment of Ship-source Oil Spill Response Capability          |
| 2   | GB/T16559-2010  | Muster List for Shipboard Oil Spillage                                             |
| 3   | JT/T 1081-2016  | Requirements on the capability of ship pollution response organization             |
| 4   | JT/T451-2017    | Requirements on preparedness capabilities to pollution incidents at waters for ports and terminals |
| 5   | JT/T1143-2017   | Technical Guidelines on Environmental Risk Assessment of Oil Spills at Waters     |
| 6   | JT/T1144-2017   | Requirements on emergency equipments and materials for oil spill response vessel   |
| 7   | GB/T34621-2017  | Oil boom                                                                           |
| 8   | JT/T1043-2016   | Floating oil bladder                                                                |
| 9   | JT/T1191-2018   | Oil spill herder                                                                    |
| 10  | GB/T21478-2016  | Ships and marine technology marine environment protection                           |
| 11  | JT/T458-2001    | Classification for oil pollution accidents from ships                               |
| 12  | JT/T451-2017    | Requirements on emergency response equipments/facilities for oil spill in terminals in ports |

3.4. Oil spill emergency drill

In recent years, the central government, local government, and port enterprises had extensively carried out oil spill emergency drills, improved emergency operations, and trained emergency teams. China also strengthen connection with neighboring countries to carrying out emergency drills together.
On 4 September, 2018, national large marine oil spill emergency response drill was held in the coastal area of Ningbo-Zhoushan port. The drill simulated a collision accident of a 200,000 tons crude oil tanker and leaked 1,000 tons crude oil. On 14 July, 2016, the NOWPAP (Northwest Pacific Action Plan) China-Korea Maritime Oil Spill Response Joint Drill was held in the seas of China Weihai. Several professional oil spill dispose vessels, professional rescue helicopter and drones participated in the drill, more than 400 participants.

4. Construction achievements of marine oil spill emergency materials in china

4.1. Construction of oil spill emergency equipment warehouses
As of 2018, 16 national oil spill emergency equipment warehouses have been built in China. Among which the 3 largest warehouses can confront 1,000 tons oil spill. Additional, 13 oil spills emergency equipment warehouses set up on the trunk line of the Yangtze River. Among these, can confronting 500, 200 or 50 tons of oil spills [26, 27, 28].

4.2. Ship pollution removal enterprises
Since 2011, China has fully implemented the administration regime of agreement for ship pollution removal. In accordance with the relevant provisions, all carrying hazardous liquid bulk and other carrying more than 10,000 gross tonnage ships should sign an agreement for ship pollution response with a qualified ship pollution removal enterprises, prior to ship entering into or leaving from a port. The rights and obligations of both parties to removing ship pollution be clarified. Up to now, CMSA (China Maritime Safety Administration) has approved more than 140 ship pollution removal enterprises, equipped with corresponding emergency equipment and staff. In the event of accident, the ship pollution removal enterprises will take pollution control and removal measures for the signed ship.

4.3. Port enterprises emergency Force
In 2012, CMSA announced 23 ship pollution risk assessment units, and has launched marine oil spill risk assessment, which has enabled the port enterprises, especially oil terminals and other large terminals to improving the response capacity rapidly. These response capacity can cope with small oil spill at the forefront of the terminal, such as oil pipe bursting and a small amount of fuel oil spillage, etc.

4.4. Other Emergency Resources
With well training, the fishermen and other volunteers are the reserve army of the emergency force, to make up for the lack of professional response team. The emergency practice of many oil spills proved that fishermen and fishing boats can play an important role in emergency response of largescale oil spill.

5. Compensation mechanism for marine oil spills
MPDCF (Marine Oil Pollution Damage Compensation Fund) and CISPD (Civil Liability Insurance for Ship Oil Pollution Damage) jointly constructed the basic framework of the China’s marine oil spill damage compensation system.

5.1. MPDCF
According to Rules for the Implementation of Management Measures for Collection and Use of MPDCF (2014), the first order of fund compensation is the emergency disposal costs for reducing oil pollution damage. On June 2015, the MPDCF management committee was formally established in Beijing, which is the highest authority for using MPDCF. This marking the compensation work of MPDCF entering the operational stage. In June 2018, MPDCF management committee held a meeting
and decided to compensate 7 claimants in the four marine oil spill pollution accidents in recent years, totaling 10.42 million yuan.

5.2. CISPD
According to Implementation Measures for CISPD (took affect in 2012, revised in 2013), all ships carrying persistent oils or non-persistent oils, as well as more than 1,000 gross tons of non-oil cargo should be insured, whether they are international or domestic vessels. Besides, all tankers and other more than 10,000 gross tonnage ships should sign a pollution removal agreement with the ship pollution removal enterprises.

6. Discussion: Challenges ahead
In the next few decades, crude oil will still an important industrial blood in the world. China still needs to import a large amount of crude oil, and the transportation of crude oil still mainly based on tanker. So China will continuous confront many challenges inevitably for the prevention and control of largescale marine oil spill.

6.1. The soft power construction of emergency equipment warehouses
The completed national equipment warehouses have been equipped with a large amount of advanced emergency equipment, materials and professionals. However, the soft power of warehouses is not constructed well now. The soft power of national marine oil spill emergency equipment warehouses should be further developed, and play a bigger role in prevention and control of largescale marine oil spill system. The soft power partly include: emergency command coordination, emergency materials database collection and sharing, emergency team training, oil spill diffusion simulation, monitoring and testing, etc.

6.2. Coordination mechanism of all emergency forces
The issue of continuously improving the coordination mechanism of all emergency forces, including national marine oil spill emergency equipment warehouses, ship pollution removal enterprises, the port enterprises, and other emergency resources. If confronting a largescale marine oil spill, it needs to dispatching a large number of emergency resources, and need a well-functioning emergency coordination mechanism. A better coordination mechanism can be achieved by improving the integrated emergency response procedure, the optimization emergency materials dispatching, daily information communication, and emergency response drills, etc.

6.3. The improvement of technical standard system
At present, there are about 40 implemented standards of marine oil spill in China, but the standard system still fails to complete the entire process of oil spill emergency response. Most of the implemented standards focuses on oil spill equipment facilities, monitoring and warning, risk prevention and assessment, damage assessment, etc. However, the standard system has not covered oil spill health and safety protection standards, bioremediation standards, oiled wildlife response, waste management, etc[25].

6.4. Daily management and maintenance fund
Partial materials - oil spill dispersants, oil containment booms, and oil absorbing materials needs regularly updated [28]. Oil skimmer and oil spill emergency disposal vessel also need daily maintenance. However, the current policy mainly focuses on building new emergency response capabilities, and insurance or fund payments for an oil spill accident. For saving operating funds, the daily maintenance of some national marine oil spill emergency equipment warehouses already entrusted to third-party professional management companies. The characteristics of the oil spill emergency forces is ‘Keep an army for a thousand days and use it for a time’, which determines that it is not a profitable industry itself. Although this way can reduce the pressure on operating fund, but the
significance of these national marine oil spill emergency equipment warehouses greatly decreased. The management and maintenance mode of the warehouses is a serious problem should to solve.

6.5. The development of new technologies in emergency response

The timeliness and accuracy monitoring of oil spill site can't meet the requirement of emergency response. Oil spill tracking and data support should keep monitoring throughout the whole process from the occurrence to the end of the accident. And the stability and reserve buoyancy monitoring of the accident ship is also difficult to meet the needs.

6.6. The oil spill coastal removal capabilities

The ability to cleaning the pollutional shoreline has not yet been formed, and the waste receiving capacity is insufficient. The spilled oil reclaimed capacity is planned to achieve at least 10,000 tons in every coastal province, 20,000 tons in Guangdong Province (longer coastline), and 30,000 tons in high risk centralized sea areas, according to MSCBP (2015-2020) [20].

7. Conclusions

China has made great achievements in the PCMPS emergency system in the past decade. It mainly includes top-level design of framework, laws and regulations, industrial policies, technical specifications, spill response team, contingency plan, etc. Moreover, with actively integrated the emergency materials invested by governments, ship pollution removal enterprises and port enterprises, an emergency system for PCMPS has been initially formed.

However, China is the largest crude oil importer in the world since 2017, and mainly by maritime transport. Compared with developed countries, China's emergency response system for PCMPS is not perfect. And it can be predicted that the continuous building of this system will be a long term task. Specifically, for minimizing the marine pollution accident threat, there are many aspects should be improving: the soft power of equipment warehouses, coordination mechanism of all emergency forces, technical standard system, daily management and maintenance fund, waste receiving capacity, monitoring of oil spill site, etc. China’s construction experiences for PCMPS would be helpful for marine environmental protection and marine economic development in east asia.

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Conflicts of Interest

The author declares no conflict of interest

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