Study on the Dangerous Chemicals Embargoed from Inland Waterway Transport

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Abstract. Safety management of chemicals transport by inland waterways is closely connected with the safety of people’s lives and property and the protection of public environmental. This work aims to study how the dangerous chemicals embargoed from inland waterway transport can be designated in China. Firstly, the safety risks and the factors that may cause safety hazards at Yangtze River are investigated. Then, the regulations for dangerous chemicals embargoed from inland waterway transport in different countries are compared. Finally, the rules for the designation of the dangerous chemicals embargoed from inland waterway transport are proposed. This work promotes the understanding of safety management of chemicals transport by inland waterways.

1. Introduction

The phenol leak originated from Gloria and “Wolong Sea” ship collision accident have caused great harm to the navigation safety and water supply safety in the Yangtze River. These experiences have shown that there are safety and eco-environmental risks of the dangerous chemicals transportation in inland waterways. International organizations, the European Union, the United States and China have adopted international conventions and domestic regulations to manage the transport of dangerous chemicals by inland waterways respectively. However, due to the huge differences in management mechanisms and transportation environmental conditions, the List of Dangerous Chemicals Embargoed from Inland Waterway Transport (LHCPIWT) from different countries varies widely. The selection rules for LHCPIWT must be studied on the basis of drawing lessons from other countries. A scientific and feasible procedure for the selection process of LHCPIWT must be proposed to ensure the safety and development of inland dangerous chemicals transportation.

2. Dangerous Chemicals Transportation in Inland Waterways

2.1. Terminals Distribution

By the end of 2017, there are 468 terminals for dangerous goods among main trunk of Yangtze River. Among them, the terminals number of Shanghai section of the Yangtze River managed by Shanghai Maritime Safety Administration, the Jiangsu section of the Yangtze River managed by Yangtze River Maritime Safety Administration, and the other sections are 24, 229 and 215 respectively. Compared with the year of 2012, the number of Yangtze River inland river terminals has been significantly reduced by 119, and the layout structure of the terminals was gradually optimized.
2.2. **Shipping Supply**

In the Yangtze River system, the main ships for the transport of bulk liquid dangerous goods in inter-provincial inland rivers are oil tankers, bulk chemical ships and bulk liquefied gas ships [1]. According to statistics by the end of 2017, there were 166 enterprises operating the transportation of bulk liquid dangerous goods in inter-provincial inland rivers of the Yangtze River system, with a total of 3039 ships, with a total deadweight of 3.28 million tons and an average deadweight of 1078 tons per ship. Compared with the year of 2012, there were 86 fewer dangerous goods carriers for liquid goods, 1071 fewer ships and 510,000 more tons of transport capacity. The transport enterprises are developing towards a large scale, and the capacity structure has been greatly optimized.

2.3. **Major Dangerous Goods Species and Transportation Volume**

Dangerous goods shipped by the Yangtze River system include all types of dangerous goods except Class 7. The bulk liquid dangerous goods are diesel, gasoline, crude oil, aviation kerosene, benzene, aniline, hydrochloric acid, liquid alkali and so on. The average volume of dangerous goods transportation on the Yangtze River trunk line has increased by more than 8% from 2011 to 2017. In 2017, the transportation volume of dangerous goods on the Yangtze River reached 223.93 million tons, and the volume of oil transportation accounted for more than 50% of the total transportation of dangerous goods. The volume of transport of dangerous chemicals in bulk increased from 49.618 million tons in 2011 to 80.79 million tons in 2017, with an average annual growth rate of 9%.

3. **Safety Risks of Inland River Dangerous Chemicals Transportation**

The risks of inland river dangerous chemicals transportation are mainly due to ship stranding, ship collision, damaged hull after hitting reef, and the resulting leakage accidents, fires and explosions, loss of life and property of people, and harm to the water environment of the river. The coastal areas along the Yangtze River have a large population, and such accidents will seriously affect the water supply safety of related cities.

According to statistics, the number of water pollution accidents caused by vessels along the Yangtze River and accidents involving dangerous goods vessels is on the decline. There have been no major water pollution accidents caused by ships for five consecutive years on the Yangtze River Main Line, which indicate a rather good safety condition. Although there have been no major water pollution accidents caused by ships in recent years, it is worth noting that due to the poor condition of some ships, collision accidents occur from time to time, and there is still a risk of water pollution accidents caused by ships.

4. **Analysis of Factors Affecting the Safety of Dangerous Chemicals Transportation in Inland Waterway**

4.1. **Environmental Factors**

Meteorological and hydrological conditions [2]:

(1) The first is the impact of wind, especially typhoons and strong gusts, which can increase the complexity and difficulty of maneuvering inland navigation vessels.

(2) The second is the impact of fog; the third is the impact of hydrological conditions.

(3) There are large differences in water levels during the high and low water periods in most water areas, which have a great impact on the berthing and un-berthing operations of ships and the safety of ships.

Navigable environment and waterway: Most of the inland rivers in China are in a natural state with low level of waterway maintenance technologies. There are shoals among certain waterways, and the waterways are affected greatly by the flood season and the tidal effect of the estuaries. Navigational facilities in some inland navigation waters are imperfect. There are too many ship lock hubs and navigating ships in the navigable waters, with huge traffic flow and much navigating level limitation in Inland Waterway. As a result, the risk of collisions, grounding and other accidents is great.
4.2. Ship Factors
Ship factors include ship age, ship tonnage, and ship technology status. In China, the dangerous goods transporting ships in inland waterway are of the various categories, different characteristics, ragged technology and management level. Old ships have poor equipment conditions, too few emergency equipment, and low anti-risk capabilities, thus bearing comparable greater accidence risk [3].

4.3. Management Factor
Organization and management factors are mainly reflected in the safety management system, including the inadequacy of regulations and standards for the transport of dangerous goods in inland waterway, the obvious lack of supervision methods, and the imperfect safety supervision system.

4.4. Human Factors
According to the International Safety Management (ISM) Code proposed by International Maritime Organization (IMO), about 80% of the accidents at sea are caused by human factors, while the proportion of ship accidents related to human factors is as high as 85-96%, which is mainly attribute to the defects of the professional quality of the crew [4].

5. Comparative Study on Management of Dangerous Chemicals Embargoed from Inland Waterway Transport at Home and Abroad
A system of laws and regulations for the management of dangerous chemicals has been formed based on international conventions and domestic regulations. Relevant international conventions include the UN Recommendations on the Transport of Dangerous Goods, International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, or MARPOL 73/78, amendments to the International Maritime Dangerous Goods Code (IMDG) code, etc. Many countries also have domestic regulations that regulate the transport of dangerous chemicals in inland waterways, such as the European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways in the European Union, the Dangerous Materials Transportation Act in the United States, and the Regulations on Safe Management of Dangerous Chemicals in China.

According to the IMDG Code, if a substance or article delivered for transportation is prone to explosion, to dangerous reactions, to flame or to dangerous heat release, or to the release of dangerously toxic, corrosive or flammable gases or vapors under normal transportation conditions, this substance will be embargoed from being transported, and 22 types of embargoed goods are listed in the IMDG code [5].

The European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) lists the catalogue of dangerous goods embargoed from transport, with a total of 12 species by category and item [6]. The United States federal regulation CFR 49 lists 256 embargoed goods, including the goods embargoed by various modes of transport, in which the list of goods embargoed from transport by waterways is consistent with the IMDG code, for a total of 22 [7].

In China, the management of the prohibition of transportation of dangerous chemicals are conducted in accordance with Regulations on Safe Management of Dangerous Chemicals (Decree No. 591). In 2015, according to the newly revised Decree 591 and the Catalog of Dangerous Chemicals in China (2015), the List of Dangerous Chemicals Embargoed from Inland Waterway Transport (2015) (Trial) was formulated and released, which specified 308 [8] dangerous chemicals that are not allowed to be transported through inland waterways.

6. Research and Application of Designation Rules of the Dangerous Chemicals Embargoed from Inland Waterway Transport
The determination of whether highly toxic chemicals and other dangerous chemicals are embargoed from being transported through an inland waterway is based primarily on factors such as the dangerous characteristics of dangerous chemicals, the degree of harm of dangerous chemicals to
humans and the water environment, and the degree of difficulty in eliminating harmful consequences [9].

The determination of the selection rules for LHCPIWT shall comprehensively consider factors such as the risk of explosion of dangerous chemicals, healthy acute toxicity, ecological toxicity, and the state in the water environment. Besides, relevant catalogues from China and foreign countries, related conventions, and transportation regulations should be combined.

In terms of the index of dangerous chemicals, the factor of the difficulty of eliminating harmful consequences has not been taken into account due to the lack of domestic data. As a result, the determination of the selection rules for LHCPIWT need to take into account the dangerous characteristics of dangerous chemicals, the degree of harm of dangerous chemicals to humans and the water environment.

In terms of the transportation form of dangerous goods, since bulk dangerous goods are usually transported in the form of whole ships or cabins. Once an accident occurs, the risk of dangerous goods leakage is very high, and it is also difficult to eliminate the impact of the accident. For dangerous goods transported in the form of a package, even if a container with the dangerous goods falls into the water due to an accident on the ship, the probability of leakage of dangerous goods is much lower than that of bulk transportation. Moreover, it is not difficult to deal with the leakage at the later stage of the accident. In the historical records, during the transportation in the form of packaging of dangerous goods other than poisonous materials, no major safety or environmental pollution accidents were caused, and the risks were controllable. Therefore, when determining the selection rules for LHCPIWT, the transportation of dangerous goods in the form of bulk needs to be strictly restricted.

In terms of the international covenant, in order to be consistent with international shipping, the embargoed varieties in the IMDG code should be included in the LHCPIWT.

In summary, considering the implementation of the List of Dangerous Chemicals Embargoed from Inland Waterway Transport (2015), the selection rules for LHCPIWT are determined as follows:

1. The highly toxic dangerous chemicals listed in the Catalog of Dangerous Chemicals in China (2015) are classified as embargoed products, and are not allowed to be transported in inland rivers by any means.

2. Dangerous chemicals classified as unstable explosives in the Dangerous Chemicals Classification Information Form are not allowed to be transported in inland rivers by any means.

3. Dangerous chemicals listed as embargoed in the IMDG code are classified as embargoed products, and transportation in inland rivers by any means is embargoed.

4. Dangerous chemicals listed in the List of Dangerous Chemicals Embargoed from Inland Waterway Transport (2015) that are dangerous to the aquatic environment-acute toxicity (category 1) and dangerous to the aquatic environment-long-term toxicity (category 1) are embargoed from being transported in the inland river by any means.

5. Dangerous chemicals that have been listed in the List of Dangerous Chemicals Embargoed from Inland Waterway Transport (2015) but are not conformed to the above rules of (a), (b), (c), (d) are embargoed in inland rivers transportation by means of the bulk package style.

In accordance with the selection rules proposed in this work, the dangerous chemicals were screened, and the List of Dangerous Chemicals Embargoed from Inland Waterway Transport (2019) was proposed. This list contains 313 dangerous chemicals, which consists of two parts. The first part is the list of dangerous chemicals totally embargoed from inland waterway transport, which contains a total of 227 dangerous chemicals. The second part is a list of dangerous chemicals that are embargoed from inland waterway transport by means of the bulk package style, which contains a total of 86 dangerous chemicals.

Six types of dangerous chemicals that are completely banned from transport in inland waterways are listed in the IMDG code proposed by IMO. Compared with the List of Dangerous Chemicals Embargoed from Inland Waterway Transport (2015) (Trial), the number of dangerous chemicals banned from transportation has been increased by seven, but the number of completely banned in
inland waterway transportation has been reduced. Detailed regulations have been made for different modes of transportation, and restrictions on the mode of transportation have been added.

7. Screening Mechanism and Scheme on the Selection for LHCPWT

In order for the selection process to be standardized and scientific, according to the requirements of Regulations on Safe Management of Dangerous Chemicals, the Ministry of Transport, together with the Ministry of Ecology and Environment, the Ministry of Industry and Information Technology, and the Ministry of Emergency Management determine the selection rules, then determine and release the List of Dangerous Chemicals Embargoed from Inland Waterway Transport.

Cities along inland rivers, especially those along the Yangtze River, rely on port construction and development. There are many large and medium cities along the Yangtze River, and the safety of loading, unloading, storage and transportation of dangerous chemicals has a great impact on the safety of the cities and residents. Furthermore, the Yangtze River is an important source of water along the Yangtze River. Once an accident such as a leak occurs, it will directly threaten the safety of drinking water for residents along the Yangtze River and may cause a catastrophic accident that seriously affects the Yangtze River's ecological environment [10]. Therefore, the List of Dangerous Chemicals Embargoed from Inland Waterway Transport has an important impact on China’s inland waterway shipping development, transportation safety and ecological safety.

In accordance with the policies and regulations, organizational structure, principles, scope, procedures, selection rules, and management requirements for the selection and adjustment of LHCPWT, the Measures for the Administration of the List of Dangerous Chemicals Embargoed from Inland Waterway Transport were proposed, which including the objective, scope of application, management responsibility, expert consultation, social opinions, announcement, selection rules adjusted, and catalogue republished. Therefore, a standardized LHCPWT designation mechanism was established to form a scientific List of Dangerous Chemicals Embargoed from Inland Waterway Transport.

8. Conclusion

The total amount of dangerous chemicals transported in China’s inland waterways has been steadily increasing year by year. The structure of the terminal layout and the capacity of ships have been optimized. The level of ship safety technology has been significantly improved. The safety level of dangerous chemicals transportation in inland waterways has been continuously improved.

The bottleneck of inland waterways transportation of dangerous chemicals is obvious. Due to the risk of fire, explosion, and leakage accidents in inland waterways transportation of dangerous chemicals, as well as the loss of human life and property and the risk of harm to the inland river water environment, a comprehensive management system needs to be established to ensure the safety of inland river transportation of dangerous chemicals.

In accordance with the principles of the United Nations Regulations, the IMO, Europe, the United States and China have combined their respective management practices and established LHCPWT with their own characteristics. The LHCPWT and types of embargoed goods in China and other countries vary widely. The selection principles should be formulated in conjunction with other relevant catalogues, conventions, and relevant provisions of transport rules from different countries. On the basis of drawing lessons from other countries, a more standardized and scientific selection mechanism, management system and LHCPWT should be established to ensure the safety of shipping and the safety of the inland river ecological environment.

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