



Research on Intelligent Monitoring Technology and Equipment for False and Concealed Declaration of Dangerous Goods in Port Containers

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Abstract. Based on the analysis of the current situation and primary causes of false and concealed declaration of dangerous goods in Chinese port containers, this research proposes intelligent monitoring methods specifically for dangerous goods in port containers by integrating a range of key technologies and equipment, such as risk perception, monitoring, early warning, and prevention and control. Through the rational resource allocation of container inspection equipment, the proposed intelligent monitoring methods are beneficial to improve inspection efficiency and accuracy, thereby improving the safety and management level of dangerous goods transportation in port container operations.

Keywords: Port Containers; Dangerous Goods; False and Concealed Declaration; Intelligent Monitoring Technology and Equipment

1 INTRODUCTION

China is a country with a large number of ports. Container, as a primary carrier of maritime cargo transportation in international trade, is a key form of waterway transportation in China. From 2015 to 2023, the container throughput at China ports generally exhibited a trend of increasing year by year [1] (The port container throughput of China from 2015 to 2023 is illustrated in Figure 1). Given the diverse features of dangerous goods such as explosiveness, flammability, toxicity, corrosiveness, and pollution, as well as the characteristics of container transportation such as its enclosed nature, long transportation time, and the involvement of multiple stakeholders, law-breakers may leverage containers to implement smuggling and entrainment activities against dangerous goods, which conversely will result in casualties, poisoning, property damage, or environmental pollution, ultimately seriously affecting the production and safety of ports.

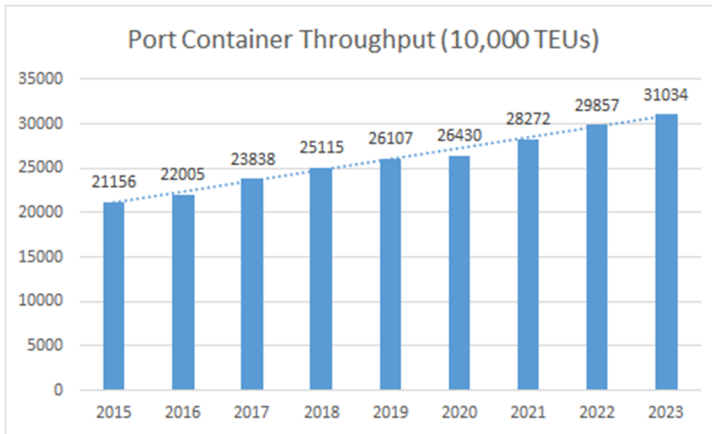


Fig. 1. Port Container Throughput of China from 2015 to 2023

2 CURRENT SITUATION OF FALSE AND CONCEALED DECLARATION OF DANGEROUS GOODS IN CHINESE PORT CONTAINERS

The demand for dangerous goods in China is notably significant. Taking into account the particularity of enclosed container transportation, some shippers exhibit various forms of misconduct, such as malicious, false, and concealed declarations when declaring dangerous goods in containers. Moreover, some shipping firms fail to go through the declaration formalities with relevant maritime administrative agencies. Under these circumstances, dangerous goods are typically managed as ordinary goods, which leads to the failure to guarantee the safety of all links from transportation, handling equipment, and storage locations to the qualification of operators. As a result, once an accident occurs, it is prone to cause huge property losses and casualties as well as adverse social impacts.

2.1 Ningbo-Zhoushan Port

Dangerous goods involved in false and concealed declarations in Ningbo-Zhoushan Port primarily encompass cosmetics, perfume, alcohol, batteries, and fireworks. Of these, more than 80% are less-than-container-load (LCL) cargoes shipped from Yiwu [2].

2.2 Guangzhou Port

In cases of false and concealed declaration of dangerous goods at Guangzhou Port in 2014, the foreign trade goods for export primarily involved fireworks and firecrackers classified as Category 1, as well as toxic substances classified as Category 6.1.

Meanwhile, domestic trade goods mainly involved dangerous chemicals, encompassing dangerous goods classified as Categories 3, 4, 5, 6, and 8 [3].

2.3 Qingdao Port

From 2015 to 2017, Qingdao Port investigated and dealt with 93 cases of undeclared dangerous goods in containers, with 41 cases involving the undeclared chemical $\text{Ca}(\text{ClO})_2$. Being classified as a Category 5.1 dangerous good with strong oxidation, $\text{Ca}(\text{ClO})_2$ can cause combustion and explosion upon contact with water or humid air. Simultaneously, it will lead to fires when in contact with organic materials and release highly toxic chlorine gas when exposed to heat, acids, or sunlight [4].

2.4 Tianjin Port

Following the 8-12 fire and explosion accident in 2015, Tianjin Port ceased the handling and storage of dangerous goods containers. Since 2017, Tianjin Port has resumed operations for Category 8 and Category 9 dangerous goods. Given the relatively strong market demand, except for some enterprises that choose to export goods through other ports, it is possible that certain enterprises take risks to ship dangerous goods in the form of false and concealed declarations [5].

3 ANALYSIS OF THE CAUSES OF FALSE AND CONCEALED DECLARATION OF CONTAINER DANGEROUS GOODS

3.1 Cost Reduction and Profit Maximization

The freight rate of dangerous goods is 50% to 100% higher than that of ordinary goods, whereas the transportation cost of a refrigerated container of dangerous goods is 150% to 200% higher than that of ordinary goods. Hence, the owner of dangerous goods sometimes tends to falsely declare dangerous goods as ordinary goods for consignment in order to reduce transportation costs and pursue maximum economic benefits. This constitutes a major cause for the concealed declaration of dangerous goods in containers.

3.2 Reduction of Declaration Process to Avoid Supervision by Competent Authorities

Transportation of dangerous goods requires more stringent and complicated documents and procedures than ordinary goods. In contrast, dangerous goods transported in the name of ordinary goods involve relatively simple declaration processes and procedures. To avoid inspection by the management department, some shippers tend to transport dangerous goods with no qualification for transporting dangerous goods without affixing dangerous goods signs.

3.3 Significant Concealment of Container Goods

The enclosed structure of the container makes it impossible to observe the goods loaded in it intuitively. At the present stage, the monitoring methods for false and concealed declaration of dangerous goods transported by containers are relatively limited and single. Currently, unpacking inspection, combined with large-scale professional equipment inspection, is utilized as the primary monitoring means. Nevertheless, various factors, such as low unpacking inspection rate, high cost, and low efficiency of large-scale professional inspection equipment, have brought severe challenges.

3.4 Prominent Contradiction between Supply and Demand of Dangerous Goods

Restricted by the qualifications of ports and ship operations, certain dangerous goods cannot be transported through regular channels. As a result, shippers resort to concealing declarations to facilitate further transportation of dangerous goods. Taking fireworks and firecrackers as an example, China is regarded as a major producer and exporter of fireworks and firecrackers. There is a substantial international demand for Chinese fireworks. Some ports, however, prohibit the shipment of containers carrying fireworks. To pursue market interests, some shippers and freight forwarders generally engage in the falsification or concealment of information concerning dangerous goods such as fireworks and firecrackers to illegally transport these containers.

4 IMPLEMENTATION SCHEME OF INTELLIGENT MONITORING TECHNOLOGY AND EQUIPMENT FOR FALSE AND CONCEALED DECLARATION OF PORT CONTAINERS

4.1 General Scheme

In combination with the actual production situation of the port, it is imperative to propose a general scheme that can not only ensure the efficiency of container vehicles entering and leaving the port but also improve the inspection ratio and accuracy of containers. To this end, as per the characteristics of the existing intelligent monitoring technology and equipment for false and concealed declaration of port containers, this research puts forward an inspection pattern involving rapid inspection, accurate inspection, and unpacking inspection. By rational resource allocation of inspection equipment, the proposed inspection pattern is capable of improving the efficiency of inspection and customs clearance. The specific scheme is illustrated in Figure 2:

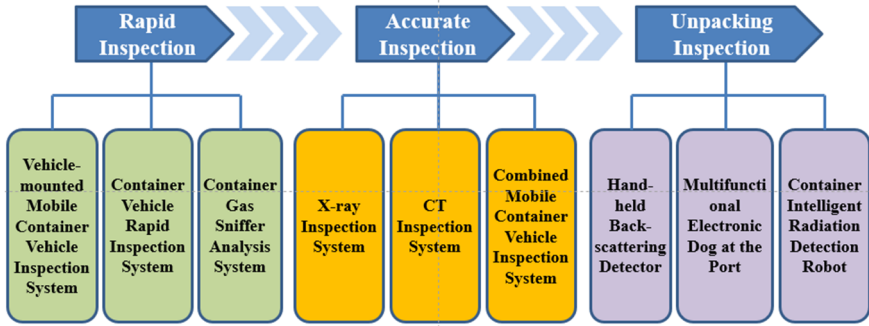


Fig. 2. Implementation Scheme of Intelligent Monitoring Technology and Equipment for False and Concealed Declaration of Port Containers

4.2 Rapid Inspection

Inspection equipment with a high inspection pass rate is installed at the gate of the port area or inspection area. As the vehicle passes through the inspection system, the rapid inspection for containers can thus be implemented. In this paper, vehicle-mounted mobile container vehicle inspection systems and container vehicle rapid inspection systems are selected to conduct real-time scanning and rapid imaging of goods within containers when container vehicles pass at low speed. Simultaneously, the integrated container gas sniffer system [6], as depicted in Figure 3, can be employed to detect and analyze the escaping gas components of the goods within containers in one scan, thus facilitating a more comprehensive evaluation of the safety and legality of the goods. Technical features of the inspection system designed for quick inspection are outlined in Table 1.

Table 1. Technical Features of the Inspection System Designed for Rapid Inspection

Items	Technical Features
Vehicle-mounted mobile container vehicle inspection system	All the equipment is integrated into the chassis of the general truck, with its passing rate being 20-25 container vehicles per hour. The pass rate of the quick scan mode is 150 container vehicles per hour.
Container vehicle rapid inspection system	With a passing rate of 120-200 container vehicles per hour, it adopts the head avoidance function to realize rapid inspection without stopping vehicles.
Container gas sniffer system	It utilizes gas sniffing technology to analyze the gas components escaping from containers, thereby providing automatic inspection and alarm for various dangerous chemicals such as toxic and harmful volatile organic compounds (VOCs), drugs or easy-to-make drugs, and inflammable and explosive articles.

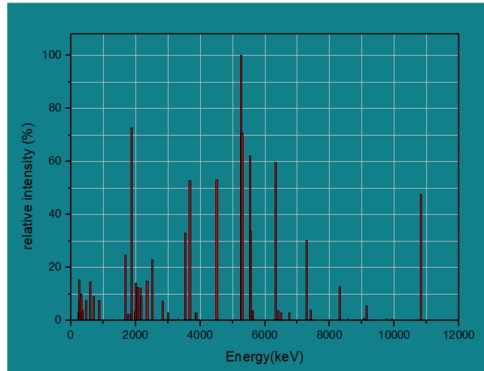


Fig. 3. Energy Spectrum during the Process of Explosive Inspection

4.3 Accurate Inspection

In scenarios where the container seal is tampered with, or the container is identified as suspicious goods upon rapid inspection, it is imperative to implement further accurate inspection to determine the category of goods within containers. Equipment with high image resolution and high definition is generally selected for accurate inspection. In this regard, this research selects an X-ray inspection system, a CT inspection system, as shown in Figure 4 [7], or a combined mobile container vehicle inspection system, as illustrated in Figure 5. High-quality images can be generated by the inspection of goods within containers by the foregoing systems, which are convenient for accurate inspection of containers. Technical features of each inspection system are shown in Table 2.

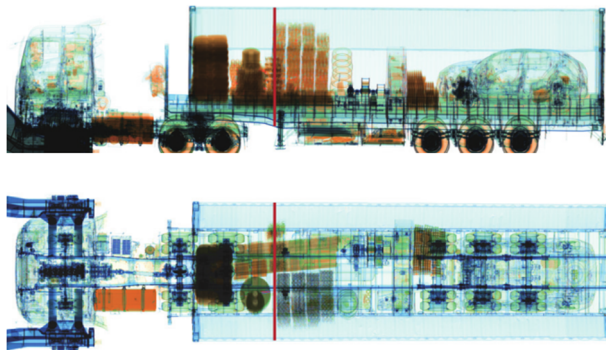


Fig. 4. Fixed Container Vehicle Inspection System (Two Orthogonal Images Generated by CT Inspection System)

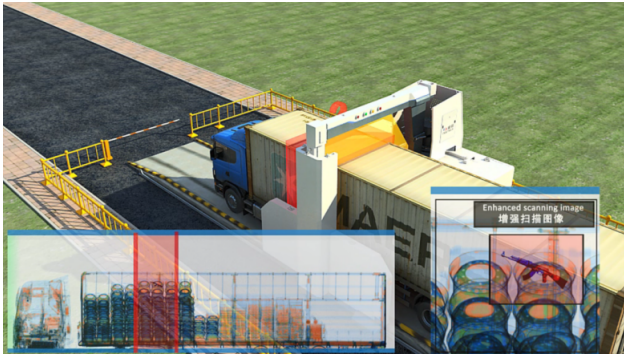


Fig. 5. Combined Mobile Container Vehicle Inspection System (Local Scanning)

Table 2. Technical Features of the Inspection System Designed for Accurate Inspection

Items	Technical Features
X-ray inspection system	With a passing rate of 30 container vehicles per hour, the system showcases significant penetration and high image quality.
CT inspection system	Using dual-energy perspective imaging technology, the system can distinguish organic matter, inorganic matter, mixture, and heavy metal, employing different colors of identification. In addition, apart from providing a dual-view DR inspection function and generating two orthogonal images, it can also perform CT tomography on suspected areas within goods and vehicles.
Combined mobile container vehicle inspection system	With the passing rate of 25 container vehicles per hour, the system can adopt high-energy substance identification technology and utilize different colors to distinguish organic matter from inorganic matter.

4.4 Unpacking Inspection

With regard to the suspected containers, manual unpacking inspection is further adopted. Specifically, operators can scan the goods within containers in a non-contact way and image them in real-time through the hand-held back-scattering detector after unpacking, which is capable of scanning the areas within containers that the relevant personnel cannot observe. Meanwhile, operators can use such functions as “smell sniffing” and “temperature monitoring” of the multifunctional electronic dog at the port to collect the escaping gas within containers in time. Moreover, the container intelligent radiation detection robot can be employed to perform nuclear radiation detection for the goods within containers.

These devices, as auxiliary devices during the manual unpacking inspection process, respectively realize the functions of image recognition, smell sniffing, radiation detection, etc. While improving the accuracy and efficiency of unpacking inspection, these devices protect the safety of unpacking operators.

5 CONCLUSIONS

To sum up, as an intelligent safety management pattern, the intelligent monitoring means for false and concealed declaration of dangerous goods in port containers furnish solid technical support and action guarantee for the management department to supervise the port dangerous goods containers. Through the early identification and prevention of container dangerous goods involving false and concealed declarations, it effectively guarantees the safety of the port with prominent intelligence.

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