



Analysis and Research on Bridge and Tunnel Accidents of Dangerous Goods Transport Vehicles in China

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Abstract. In recent years, accidents in the transport of dangerous goods have occurred frequently and have shown a rapid upward trend. The danger of dangerous goods transport vehicles passing through key areas such as bridges and tunnels cannot be ignored. Combining the causes of accidents, this paper analyzes three typical accidents involving dangerous goods transport vehicles passing through bridges and tunnels and summarizes the management problems of transport management enterprises, highway operation enterprises, and dangerous goods transport enterprises. For staff education and training, vehicles, roads, and dangerous goods transport management, we pertinently put forward some safety suggestions, hoping to provide some references for improving the management level of dangerous goods road transport.

Keywords: Dangerous goods transport · bridge and tunnel · accident analysis

1 Introduction

To ensure the safety of road traffic and transport, China has formulated relevant laws and regulations on the transport of dangerous goods and has taken certain restrictions on the transport of dangerous goods on some expressways, especially tunnels and bridges. Meanwhile, the restrictions on the transport of dangerous goods have also generated a series of problems. On the one hand, the tunnels and bridges of the expressways are the key nodes in the road network, and it is difficult to detour. The detour will lead to a substantial extension of the transport distance of dangerous goods, thus increasing the transport cost. On the other hand, restrictions will induce people to take risks to conceal transport and conceal passage, which makes the transport of dangerous goods out of supervision, and forms more hidden dangers. In recent years, there have been many major road transport safety accidents of dangerous chemicals across the country. Among them, Baotou-Maoming expressway methanol transport explosion accident on August 26, 2012, the Jincheng-Jiyuan expressway methanol transport tunnel explosion accident on March 1, 2014, and the 2014 “7.19” Shanghai-Kunming Expressway ethanol transport fire accident on July 19, 2014, killed more than 30 people. The safety management of road transport of dangerous goods has aroused widespread concern in society.

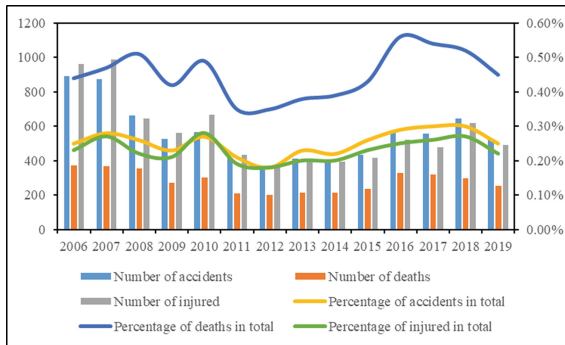


Fig. 1. Statistical chart of dangerous goods transported by vehicles involved in the accidents from 2006 to 2019

2 Overview of Dangerous Goods Transport Accidents

In recent years, accidents in the transport of dangerous goods have occurred frequently and have shown a rapid upward trend. Compared with ordinary vehicle accidents, once a dangerous goods vehicle has an accident, it is not only the casualties and property losses caused by the accident itself but also the secondary disasters caused by the leakage of its own transport products, which lead to incalculable consequences such as catastrophic mass deaths and injuries and environmental pollution. According to the statistics of the accidents caused by the transport of dangerous goods in *the Annual Report on Road Traffic Accident Statistics of the People's Republic of China* (Fig. 1), the number and proportion of dangerous goods transport accidents from 2006 to 2010 were relatively high. However, with the revision and implementation of *Regulations on the Safety Management of Hazardous Chemicals* (No. 591 of the State Council) in 2011, the number and proportion of dangerous goods transport accidents dropped significantly from 2012 to 2013. After 2013, the number and proportion of accidents have increased due to the increase of new projects, production enterprises, transport business of dangerous goods, and the reduction of law enforcement efforts. It brings dangers that cannot be ignored to the safety of the areas through which dangerous goods are transported, especially bridges, tunnels, densely populated areas, and other key areas.

3 Analysis of Accident Consequence

Due to the fact that there are simple procedures for handling traffic accidents in China, and the publicity of accident statistical data is relatively low, the accident statistics of dangerous goods transport vehicles that do not leak after the accident are distorted, therefore, this paper only analyzes the leakage, fire, and explosion after the accident of the dangerous goods transport vehicle. Through the statistical analysis, the leakage accidents of dangerous goods account for 91%, the burning accidents of dangerous goods account for 8%, and the explosion accidents of dangerous goods account for 1%. The statistical distribution of the consequences of dangerous goods transport accidents is shown in Fig. 2 [1].

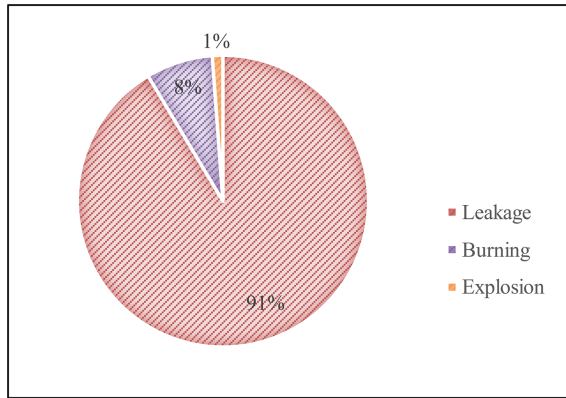


Fig. 2. Statistical distribution chart on consequences of dangerous goods transport accidents

In the event of an accident with a vehicle transporting dangerous goods, sparks may occur when the vehicle body collides with fixed objects or other vehicles. Combustion and explosion are produced simultaneously in an accident collision. The timeliness and effectiveness of the accident rescue statistics in this paper have restrained the late combustion and explosion of the leaks. Among the consequences of dangerous goods transport accidents, leakage accidents account for the highest proportion, while combustion and explosion accidents account for a lower proportion. However, depending on the type of dangerous goods, it is not possible to evaluate the accident hazard solely based on leakage, fire, and explosion. For example, after the leakage of toxic substances and radioactive substances, it is easy to cause major harm to the surrounding people and the environment. Therefore, we should not only focus on combustion and explosion accidents, and leakage accidents should not be ignored either [2].

4 Problem Analysis of Typical Accident Cases

4.1 Accident in Yantai Laizhou Section of Rongcheng-Wuhai Expressway on January 16, 2015 [3]

4.1.1 Overview of the Accident

A major road traffic accident involving four vehicles (a Wuling minivan of Lu YMA331, a Jiefang heavy tank truck loaded with gasoline of JR2887, a large ordinary bus of Lu F28955, and a small off-road bus of Lu K92039) collision occurred on the Yinmachi Bridge of Yantai Laizhou Section of Rongcheng-Wuhai expressway at about 17:52 on January 16, 2015. The sparks from the collision caused the mixture of gasoline vapor and air leaked from the tanker to detonate, causing 12 deaths, 6 injuries, and 4 vehicles damaged in different degrees, with a direct economic loss of about 11 million yuan.

4.1.2 Management Problems Behind the Accident

The safety management duty of passenger transport enterprises is insufficient in transport management, such as the supervision and inspection responsibilities of the main body of

passenger transport safety management. The duty for qualification supervision of road dangerous goods transport management personnel is insufficient. The qualification certification and supervision and inspection of the management staff for the transport and handling of road dangerous goods are not carried out. The highway management department is ineffective in performing the duties of highway inspection and snow clearing and anti-skidding. The inspection frequency and intensity are insufficient in rain and snow weather. Snow removal and ice removal are not carried out in time for key road sections such as the Yinmachi Bridge, where the incident occurred. The main responsibility for the safe production of dangerous goods transport in enterprises is not implemented. The safety management system is useless, and the daily safety management is seriously lacking. All the registered vehicles are affiliated vehicles and are allowed to run freely. The affiliated vehicles are ignored, and the drivers of the affiliated vehicles do not receive safety education and training.

4.2 Accident of Yanhou Tunnel in Shanxi Jincheng Section of Jincheng-Jiyuan Expressway on March 1, 2014 [4]

4.2.1 Overview of the Accident

The Jin E23504/Jin E2932 articulated train carrying 29.14 tons of methanol collided with the Yu HC2923/Yu H085J articulated train carrying 29.66 tons of methanol in the Yanhou tunnel of Shanxi Jincheng Section of Jincheng-Jiyaun expressway in Zezhou, Jincheng city, Shanxi province, at about 14:45 on March 1, 2014. Methanol leak in front car catches fire. Two other dangerous chemical transport trucks and 31 coal transport trucks. Stranded in the tunnel were ignited and detonated, causing 40 deaths, 12 injuries, and 42 vehicles burning down. The tunnel was severely damaged and the direct economic loss was 81.97 million yuan.

4.2.2 Management Problems Behind the Accident

The transport management department is ineffective in supervising the safety of road transport of dangerous goods. For example, the supervisions of the driving recorder terminal that cannot be operated for a long time, the safety education and training of employees, and the vehicle affiliation operation are poor. The approval is valued but the supervision is despised. The supervision and guidance responsibilities are insufficient, and the safety production inspection and special inspection are not in-depth. The legal representative of the enterprises cannot effectively perform the responsibility of the first responsible person for production safety. The enterprises have the problem of "hosting by contract". The preparation of enterprise emergency plans and emergency drills does not meet the specified requirements. The enterprises do not fill the medium as designed. The safety training and education system for practitioners is not implemented, and drivers and escorts habitually operate illegally. The ball valve at the root of the discharge pipe at the bottom of the tank is open for a long time. The vehicle involved in the accident continues to operate after the dash cam breaks down.

4.3 Accident in Futuyu Tunnel No. 5 of Zhangjiakou-Shijiazhuang Expressway in Baoding, Hebei on May 23, 2017 [5]

4.3.1 Overview of the Accident

A heavy-duty semi-trailer truck (M22001/M7876) carrying 32 tons of sodium chlorate exploded in Futuyu No. 5 Tunnel (Shijiazhuang direction) of the Zhangshi Expressway at 6:23 on May 23, 2017. The accident affected 9 vehicles, 6 of them were damaged, 15 people were killed and 3 people were severely burned. The accident affected 43 houses under the high-speed bridge, and 16 villagers were slightly injured. Road facilities and buildings were damaged to a certain extent, resulting in a direct economic loss of more than 42 million.

4.3.2 Management Problems Behind the Accident

The safety supervision of the relevant transport departments is insufficient. The supervision and inspection of the road freight market are not strictly carried out. The supervision and rectification of the hidden safety hazards and problems existing in the relevant enterprises are not effective. The enterprise safety production management is lacking. The vehicle safety routine inspection system and safety training system are not strictly implemented. The violations of laws and regulations are prominent, such as unauthorized modification of vehicles for transporting dangerous chemicals, covering up dangerous goods transport warning signs to camouflage transport, dangerous goods packaging that does not meet specification requirements, illegal distribution, and using tarpaulins without fire protection, etc.

5 Typical Management Problems

By analyzing the basic situations of domestic dangerous goods transport accidents and typical dangerous goods transport accidents, the following conclusions are drawn.

- (1) Most of the dangerous goods transport accidents are leakage accidents, and the proportion of dangerous goods burning and explosion accidents is relatively low.
- (2) The main problems of transport management enterprises are inadequate management, supervision, inspection, and guidance; inadequate supervision and inspection of potential safety hazards and problems rectification; inadequate work of “fighting against illegal”; lax scrutiny.
- (3) The main problems involving highway operation enterprises are insufficient frequency and intensity of maintenance inspections in rainy and snowy weather; inadequate development and implementation of emergency plans; irregular information monitoring and inadequate system implementation; failure to report the problem of highway congestion in time and failure to take effective measures to relieve it in time; and no safety inspections on key road sections.
- (4) The main problems involving dangerous goods transport enterprises are incomplete safety management system; unimplemented driver’s internal record; ignoring the affiliated vehicles; insufficient safety education, training and assessment

for employees; non-compliant emergency plans preparation and emergency drills; over-qualified, over-scope, over-filled and illegally filled goods; illegal modification of transport vehicles; failure to check the qualifications of drivers and escorts; inadequate daily safety inspections; failure to strictly implement the vehicle dynamic monitoring system; incomplete relevant licenses, and no dangerous goods road transport license; and illegal transport of dangerous goods by ordinary trucks under camouflage.

6 Suggestions

There have been many road transport accidents of heavy and extremely heavy dangerous goods in China, revealing that major safety risks still exist within a certain range, such as illegal consignment, illegal transport, and unqualified tanker running with illness. It is indicated that there are still some loopholes in the management of road transport of dangerous goods. It is recommended to strengthen management from the following aspects.

6.1 Personnel Education and Training

Road transport enterprises must strictly implement the relevant requirements of *Regulations on the Administration of Road Transport Practitioners* and *Measures for the Continuing Education of Road Transport Drivers*. Personnel who have not received safety production education and training and who are unqualified shall not be allowed to work. Regulatory departments should strengthen supervision and inspection, and promote the continuous deepening of safety education for full-time safety managers, drivers, loading and unloading managers and escorts.

Driver training and education methods should be innovated, and traffic safety publicity models should be innovated. Training, education, and publicity should adopt diversified methods, such as discussion, game, case analysis, etc. It is recommended to promote the establishment of several targeted road transport safety warning education bases. The base should be based on modern information technology, integrating knowledge, fun, interactivity, and experience, and carry out immersive traffic safety publicity and education. Pre-job and daily education and training are provided to drivers through the warning education base to improve the safety awareness and knowledge and skills of relevant personnel, and encourage the public to actively understand road traffic safety knowledge, thus fundamentally reducing and avoiding road transport accidents.

6.2 Vehicles

Transport vehicles should maintain, test, use and manage special vehicles in accordance with the regulations on vehicle management in *Technical Management Regulations for Road Transport Vehicles* to ensure that special vehicles are in good technical condition. The *Measures for the Dynamic Supervision and Administration of Road Transport Vehicles* should be strictly implemented based on the road transport vehicle satellite positioning system platform and the vehicle terminal. Full-time monitoring personnel

should be provided in accordance with the requirements of laws and regulations, and the relevant systems for monitoring personnel training and post-employment after passing the examination should be strictly implemented. The qualified enterprises can add active safety facilities such as lane departure warning systems and rear-end collision warning systems, and rely on scientific and technological means to remotely monitor and intervene in the driving behavior of drivers and the situation of occupants in the vehicle to improve the safety of transport vehicles. In view of the low safety performance of the vehicle braking system and the uncoordinated braking of tractors and trailers, it is recommended to carry out in-depth research on vehicle safety technical inspection technology, improve vehicle technical inspection capabilities, increase inspection items for the braking coordination of tractor and semi-trailer, and formulate complete vehicle pairing standards for semi-trailer tractor, semi-trailer, and synchro valve.

6.3 Roads

The construction of traffic safety facilities and maintenance investment should be guaranteed. Technical training for construction and maintenance personnel should be increased to enhance the relevant personnel's awareness and understanding of the key clauses and key indicators of the standard specifications, thus avoiding one-sided understanding and rigid copying of the standard specifications. The design, construction, acceptance, and maintenance of protective facilities and signs should be improved according to the standards.

6.4 Dangerous Goods Transport Management

Firstly, we should strictly control the transportation of dangerous goods. According to the national standard *General Specifications for Transport Packages of Dangerous Goods* (GB12463), the hazard degrees of dangerous goods are divided into grades I, II, and III, and different packages are needed to be equipped as required. Packing dangerous goods is a key means to ensure the safety of dangerous goods transport. The transport packages of dangerous goods do not meet the standard specifications, which may lead to chemical reaction accidents during transport, or aggravate the consequences of accidents under special circumstances such as shocks and collisions during transport. For example, the accident of Futuyu No. 5 Tunnel of Zhangshi Expressway in Baoding in Hebei Province on May 23, 2017. One of the important reasons is that the shipper used ton bag packages that did not meet the standard specifications and was over-standard to transport sodium chlorate. According to *Safety Management Measures for Road Transport of Dangerous Goods, Regulations for Management of Road Dangerous Goods, Part 4 of Rules for the Road Transport of Dangerous Goods: Requirements for the Use of Transport Packages (JT/T 617.4), Part 5 of Rules for Road Transport of Dangerous Goods: Consignment Requirements (JT/T 617.5)* and other laws, standards and regulations, the shipper should properly pack dangerous goods, set flags on the external packings, explain the name, quantity, hazards, emergency measures of the dangerous goods to the carrier and submit material safety data sheets and safety labels that are completely consistent with the dangerous chemicals in the consignment as required.

Secondly, we should strictly make standard consignment lists in accordance with the requirements. The consignment list is not only an important carrier for recording and transmitting the information of dangerous goods transport, but also an important certificate for dangerous chemical production enterprises to assume responsibilities and fulfill obligations. The information contained in the consignment list of dangerous goods includes shipper, carrier, consignee, loader, origin, destination, category, item, name, number, package, specification, quantity, emergency contact number, dangerous characteristics, notes for transport precautions, first aid measures, fire protection measures, leakage emergency disposal, secondary environmental pollution disposal measures and other relevant information of dangerous goods. This information is very important for transport safety assurance and the emergency disposal of accidents of dangerous goods. Hiding the information or giving false information is not allowed.

Thirdly, we should strengthen the identification management of road transport enterprises. On the one hand, the source management of dangerous goods transport needs to be strengthened. On the other hand, the ability and management level of downstream enterprises of dangerous goods transport are directly related to transport safety and service quality. Dangerous chemical production enterprises should establish a strict transport enterprise management system, rules, and regulations, and clarify management requirements. They mainly include enterprise identification systems, vehicle identification systems, grading evaluation standards, and exit mechanisms. The grading evaluation standard should be comprehensively evaluated from the basic situation of the enterprise, the routine inspection situation of the enterprise, and the quality reputation assessment of the industry management department; the dynamic elimination system needs to be established based on the grading evaluation standard, which is helpful to consignment, carriage, loading and unloading, vehicle operation and other links, and staff, vehicles, tanks, packings, labels, signs and other elements of dangerous goods of enterprises. We should make efforts to construct the whole chain management system for road transport of dangerous goods.

7 Conclusion

In summary, there are still many problems in the transportation management of dangerous goods in China. Regulatory departments should strengthen supervision and inspection, and promote the continuous deepening of safety education for full-time safety managers, drivers, loading and unloading managers and escorts. Transport vehicles should maintain, test, use and manage special vehicles in accordance with the regulations on vehicle management in Technical Management Regulations for Road Transport Vehicles to ensure that special vehicles are in good technical condition. Regulate the construction and maintenance of traffic safety facilities. At the same time, the transportation and packaging of dangerous goods should be strictly controlled. Standard consignment list should be made according to the requirements, the identification management of road transport enterprises needs to be strengthened. Close the loopholes in the management of road transport of dangerous goods.

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