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Study on Safety System for Road Transportation of Dangerous Chemicals

LIU Hui SUN Shimei ZHANG Zhichao
School of Municipal and Environmental Engineering
Jilin Architectural and Civil Engineering Institute
Changchun Jilin China
Lhsafety@163.com

***Abstract*-In order to ensure the safety of road transportation of dangerous chemicals, study model for safety system of road transportation of dangerous chemicals is established from the perspective of accident prevention, safety guarantee, safety assessment and accident rescue, a comprehensive and effective safety system of road transportation of dangerous chemicals is built up, which is composed of four parts, safety assurance system, safety check system, safety assessment system and emergency rescue system, each part is self-links. This laid a theoretical foundation for safety guarantee, accident prevention and accident rescue for road transportation of dangerous chemicals, but also provides a theoretical basis for safety management for road transportation of dangerous chemicals.**

Keywords-road transportation; dangerous chemicals; safety system; safety guarantee; safety check; safety assessment; emergency rescue

I. INSTRUCTION

In recent years, with rapid economic development, production volume and transportation volume of hazardous chemicals was increased year by year, according to statistics, there were 7,274 road dangerous freight companies, 132,200 all kinds of transportation vehicles, more than 60 million employing people. China's annual road transportation by about 200 million tons of dangerous chemicals, more than 3,000 species, of which 1 million tons of explosive fuel, liquid chlorine transportation capacity of 400 million tons per year, the annual transportation capacity of liquid ammonia 300 million tons. Accounts for Transportation of dangerous goods in China are more than 30% of total freight. According to Ministry of Public Security, the first half of 2007, total road transportation of dangerous chemicals from the 207 accidents, resulting in 154 deaths, up 31.6% over last year. According to statistics, in the dangerous chemicals production, storage, management, transportation, use and other sectors caused by accident, the accident rate of transport links more than 30%.

Road transportation of hazardous chemicals is a high risk industry, relative to production, management, storage, use four links in the state of inter-regional flows, which is the focus and difficult of safety management, involving dangerous chemicals, transport vehicles, related personnel, road conditions, surrounding environment, transport links, in the event of an accident, it will cause heavy casualties and property losses, road transportation safety of hazardous chemicals has become the current focus of attention. In this paper, road transportation safety of hazardous chemicals was study from accident prevention, security, safety evaluation and accident rescue， a sound and effective road safety system of transportation of dangerous chemicals was established.

II. SAFETY SYSTEM FOR ROAD TRANSPORTATION OF DANGEROUS CHEMICALS

Safety system of road transportation for dangerous chemicals is mainly of safety check system for dangerous chemicals transportation, safety evaluation system for road dangerous chemicals, and safety assurance system for road transport of dangerous chemicals, emergency rescue system for road transportation of dangerous chemicals of four components, as was shown in Figure 1.

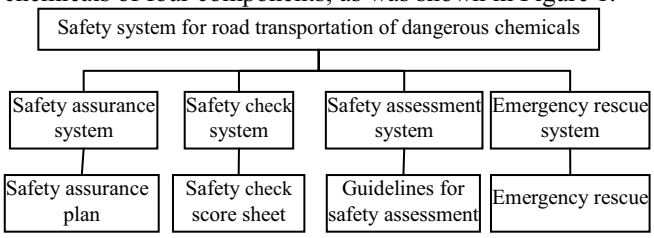

Fig. 1. Safety system of road transportation for dangerous chemicals

III. SAFETY ASSURANCE SYSTEM FOR ROAD TRANSPORTATION OF DANGEROUS CHEMICALS

A. Safety Assurance System

With the existing situation with transportation enterprises, through summarizing and enhancing the internal relations and theoretical law of other safety management activities and operation for the successful road transport of hazardous chemicals, a series of elements were concluded, the discrete disorder safety management activities were considered under a unified whole, the safety assurance system of road transport for dangerous chemicals was established, which is safety management document within the road transport of dangerous chemicals enterprise on the whole process, but also the relevant technical standards required supplement

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on the security technology for road transport of dangerous chemicals, and an important guarantee for transportation safety.

Road transport companies of dangerous chemicals should establish and maintain safety assurance system a road transportation for dangerous chemicals as an important foundation work, prepare a complete safety system files, make system files design, implementation, evaluation and continuous improvement, so that transportation companies to book transportation behavior, evaluate and improve the safety system is to achieve continuous improvement, an essential basis for accident prevention.

Safety assurance system files of road transportation for dangerous chemicals are divided into the applicable laws, regulations, standards, specifications and other required documents, and the transportation safety assurance system, two types of files.

Safety assurance system files of road transportation for dangerous chemicals generally include:

⑴Safety goals;

⑵Safety assurance plan;

⑶Prevention and control measures of major hazard installations and significant adverse environmental, such as special safety measures, emergency plans;

⑷Safety procedures, rules and regulations, operating instructions and other documents;

⑸Safety materials procurement and safety agreements;

⑹Safety record.

B. Safety Assurance Plan

Safety assurance plan calls for completing the preparation before the start of transport, based safety system requirements of transport companies of dangerous chemicals, and revolve safety objectives of transport companies, through safety planning, control measures provided, resources and activities order. Safety assurance plan not only to describe the safety controls on the transport process, while also confirmed to the relevant parties to ensure the safety of transport capacity of enterprises. Safety assurance plan can be linked to the specific requirements of the safety management for transport process and common procedures of existing safety management of the company, and existing safety laws, regulations and standards of industry, the Government, which can be used to judge whether a company followed safety assurance system requirements.

IV. SAFETY INSPECTION SYSTEM FOR ROAD TRANSPORTATION OF DANGEROUS CHEMICALS

A. Safety Inspection System

Road transportation companies of hazardous chemicals should establish safety inspection system of road transportation for dangerous chemicals in terms of safety management, and safety assurance system of road transportation for dangerous chemicals engineering format transportation safety guarantee of dangerous chemicals, safety check system for road transportation of dangerous chemicals [1] was shown in Figure 2.

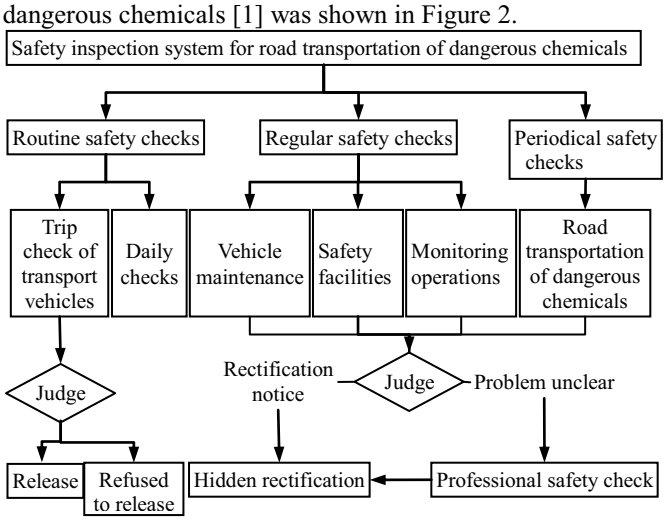

Fig. 2. Safety check system for road transportation of dangerous chemicals

B. *Safety inspection score sheet*

According to the inspection area of safety inspection system, and combines the results of hazard identification, and safety inspection score sheet of road transport companies of dangerous chemicals was prepared, basic approach of safety administration is in accordance with requirements of the safety inspection procedures and the contents of safety check list to do safety check.

1) Preparation principles of safety inspection score sheet

The safety check list items of dangerous chemicals transportation is determined based on hazards identification of the road transport of dangerous chemicals, the various projects identified were analyzed by system safety analysis method, which can improve the accuracy of hazard identification from different angles and different levels.

Hazard identification work of a comprehensive road transport of dangerous chemicals should not rigidly adhere to several methods of the above, the actual identification need several ways simultaneously, making it more full recognition, scientific, reliability and credibility.

Projects determined were carried on analysis of the feasibility of the implementation in hazard identification process, in the end can be implemented on the basis of analysis, combined with relevant laws and regulations, determine the evaluation checklist as the contents of a safety check list.

2) Preparation of safety inspection score sheet

(1)Road transport safety of hazardous chemicals divided into different types from different angles, such as: from the perspective of transport links, can be divided into packaging, filling and loading, transportation, unloading, vehicle maintenance and other aspects of security; from the system angle can be divided into qualifications, operating conditions, transport vehicles

and equipment, transportation of dangerous goods, safety management.

The evaluation index system established by different classification criteria, while in theory should have the same effect, but in practice have a great impact for application flexibility, operability. A more complete safety check list for road transportation of hazardous chemicals was prepared by the various subsystems, that is "safety inspection score sheet for road transportation of dangerous chemicals."

(2)Determine assignment principles and methods of the safety inspection checklist items.

(3)Determine evaluation standards of the safety checklist.

(4)Implement the evaluation of the total score calculated and analyzed the object and the evaluation criteria identified by comparison, are evaluating the results. According to the results take appropriate safety measures.SAFETY ASSESSMENT SYSTEM FOR ROAD TRANSPORTATION OF DANGEROUS CHEMICALS

A. Structure of Assessment Index System

Safety assessment system of road transportation for dangerous chemicals is a self-improvement system, which has self-contained safety assessment guidelines and safety assessment methods, but not divorce from the environment of road transport, and integrate related systems of road transport enterprises. The purpose of establishing assessment index system is to evaluate safety state of road transportation enterprise of dangerous chemicals. Before the establishment of assessment index system, relevant information should be collected, including relevant laws and regulations, systems safety theory, industry characteristics and so on. Then, index system was initially developed, and refers the views of relevant experts, and finally formats index system. Based on the above analysis, safety assessment index system of road transportation for dangerous chemicals was established.

A safety assessment index system structure combined by accidents and hazards of road transportation of dangerous chemicals was initially established, that is “safety inspection score sheet of highway transportation for dangerous chemicals."

Assessment Index System

The selection and determination of assessment index system is the basis and key of evaluate and research content, which directly impact results and accuracy of the evaluation. Actual safety assessment index system is not better indexes, assessment indexes play the role in the evaluation is of the key, as little as possible of the important indexes for the actual evaluation should be selected by the general principles. Reference to road transport system structure of dangerous chemicals, shape and characteristics of road traffic accidents for dangerous chemicals, the reality of the environment for road transport of dangerous chemicals, according to purposes and principles of assessment index system for road transport of dangerous chemicals, combining "safety inspection score sheet of highway transportation for dangerous chemicals," the index system was simplified, and to seek expert advice, build safety assessment index system frameworks of road transportation for dangerous chemicals, such as Table I.

TABLE I SAFETY ASSESSMENT INDEX SYSTEM FOR ROAD TRANSPORTATION OF DANGEROUS CHEMICALS

Overall objective	One level index	Two level index
The state of road transport companies of dangerous chemicals	Employed qualification	Enterprise qualification
		Organizational structure
		Employees
	Business conditions	Site conditions and facilities
		Road conditions and road facilities
		Environmental conditions
	Transportation vehicles and equipment	Vehicle qualification
		Technical conditions of safety facilities of vehicles
		Technical condition of vehicles equipment
		Vehicle maintenance
	Transportation of dangerous goods	Carrier acceptance
		Safe operation of vehicles
		Loading and unloading operations safety
	Safety management	Safety regulations
		Safety education and training
		Potential accidents and emergency rescue

C. Safety assessment

There are mainly qualitative indexes in indexes determined of safety assessment system of road transportation for dangerous chemicals, in the process of quantitative indexes, values determination of qualitative indexes and safety assessment of enterprise were assessed together.

A fuzzy mathematical method was used to safety assessment of road transport of dangerous chemicals; there are 3 common methods on the weights determination of indexes: Delphi method (expert evaluation method), the level analysis and relative comparison. Whether the process of weight determination was correct or not, directly determines the accuracy of evaluation results. The weight was determined by expert evaluation method, the participation of experts in all aspects of personnel, combined with my own experience and the specific situation of transportation enterprises determine the weight, lack of experience and failure of staff structure was avoid, which causes a biased assessment.

Factors evaluation set of road transportation system of dangerous chemicals is determined by the judges scores, and 10-member safety group was selected from the safety expert database of highway transportation for dangerous chemicals, the single factors under the guidelines layer were evaluated respectively by evaluation set of the system, which get the evaluation set.

Meanwhile, safety fuzzy evaluation method was studied and applied, a fuzzy mathematical model for safety assessment was established [2], the evaluation results were determined by the principle of the fuzzy maximum membership degree, there will be some uncertainty, in order to get the adapt evaluation results, rank of evaluation results is percentile, which has better evaluation results.

D. Safety Assessment Guidelines

Safety assessment for production, management, storage and use enterprise of dangerous chemicals was based primarily on the related safety assessment guidelines, safety assessment for transportation enterprises of dangerous chemicals has no specific guidelines for safety assessment, the system combined with safety assessment guidelines for production, management, storage enterprise of dangerous chemicals and the actual situation of transport enterprises, built safety assessment guidelines for the road of dangerous chemicals, which provide guidance to safety assessment for road transportation enterprise of dangerous chemicals.

VI. EMERGENCY RESCUE SYSTEM FOR ROAD TRANSPORTATION OF DANGEROUS CHEMICALS

A. Emergency Rescue System

On the basis of investigation and analysis for hazard installations and emergency rescue [3-5] of road transportation of dangerous chemicals, and organization and coordination agency of emergency rescue was established by Safety Supervision Bureau; Rescue professional staff of dangerous chemicals were established by police and fire rescue departments; The development of emergency rescue plan, establishment of computer-aided decision making system for transport of dangerous chemicals; Police and fire rescue departments with emergency rescue equipment and apparatus. Emergency rescue system for municipal, provincial and national road transportation enterprises of dangerous chemicals were established, the system was composed of file system for transport enterprise of dangerous chemicals, command system of Emergency organization, guarantee system of Emergency organization and technology systems of emergency Monitoring of 4 aspects, emergency rescue system for road transport of dangerous chemicals as was shown in Figure 3.

B. Emergency Rescue Plan

Transportation enterprises should develop appropriate emergency rescue plan for leak, poisoning, fires and explosions accidents may occur in the transport process, prepare for emergency rescue supplies, and organize the implementation in the accident time, which prevent the accident and reduce the related injuries and adverse environmental impacts.

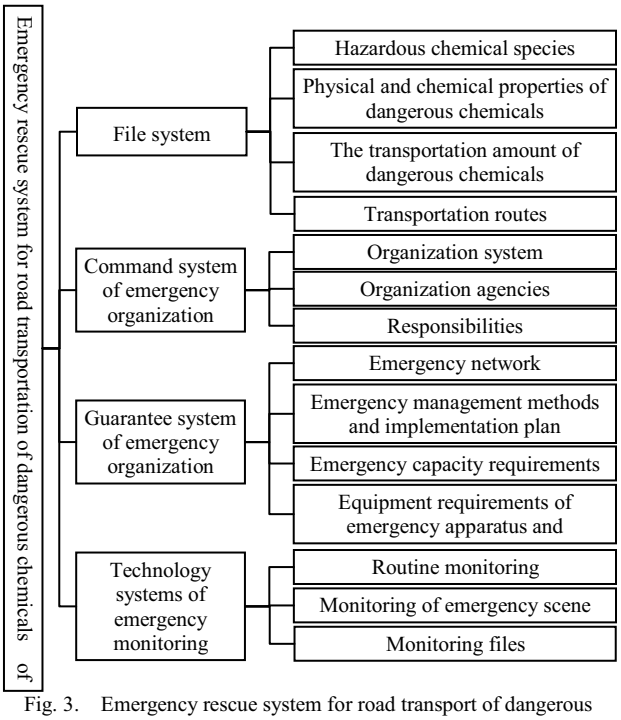

Fig. 3. Emergency rescue system for road transport of dangerous chemicals

VII. DISCUSSION

Safety research model of safety system for road transportation of dangerous chemicals was established from the accident prevention, safety guarantee, safety assessment and accident rescue angle, which need deeply study on safety inspections system for road transportation of dangerous chemicals, safety assessment system for road transport for dangerous chemicals, safety assurance system for road transportation of dangerous chemicals, emergency rescue system for road transportation of dangerous chemicals of four parts, the study of each part is an independent, cross-cutting, and laid a theoretical foundation for the safety guarantee, accident prevention, accident rescue for road transportation of dangerous chemicals, and but also provide a theoretical basis to safety management for road transportation of dangerous chemicals.

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