

## Research on the Road Transport Risk of Domestic Hazardous Chemicals

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***Abstract:*** In recent years, heavy traffic accidents of hazardous chemicals road transport in China have occurred sometimes, both the loss of dangerous goods itself and the damage to the vehicle, to bring considerable property damage to the enterprise, but also a threat to the people who live in the place where the accident happened and ambient environment. In this paper, we first collect data of 61 cases of road safety accidents in the past three years, and identify the factors that affect the risk control of hazardous chemicals road transport from five aspects: man, machine, material, method and environment and draw a Fishbone Diagram. Then it is need to carry out a risk assessment and make a risk matrix. Finally, some suggestions and measures on risk control are given to establish a simple and easy to understand and effective risk control system for enterprises. I hope the domestic hazardous chemicals road transport enterprises to further improve, develop and improve.

***Keywords:*** hazardous chemicals; road transport; risk identification; risk control

### I. INTRODUCTION

In recent years, with the development of production technology and production scale expansion in petrochemical industry, chemical logistics is booming. Because of the nature of hazardous chemicals, it is easy to have explosion, fire, leakage and other accidents, caused huge losses to individuals, businesses and society. Hazardous chemicals transport as a high accident rate of a link hazardous chemicals from production to waste, its security cannot be underestimated

The purpose of this research is to analyze the accidents occurring in the road transport of hazardous chemicals in China, and to make a risk assessment based on the Fishbone Diagram from risk factors of hazardous chemicals road Transport, then to make a risk matrix diagram. Finally, some recommendations and measures will be suggested for hazardous chemicals road transport enterprises to strengthen their risk control and improve the safety of operation.

### II. CURRENT SITUATION OF DOMESTIC RISK MANAGEMENT OF HAZARDOUS CHEMICALS ROAD TRANSPORT

The legislation and law enforcement system of Hazardous chemicals road transport management in China began to establish in 1980s , The first stipulation was made by the Ministry of Transport named "Provisions on the Administration of Road Transport of Dangerous Goods", followed by the state issued a "Provisions on the safety management of chemical dangerous goods ".

China's hazardous chemicals logistics management system began to normalization until the Work Safety Law of the People's Republic of China and Regulation on the Safety Management of Hazardous Chemicals" promulgated in 2002.

State Administration of Work Safety statistics show that China occurred a total of 326 various types of hazardous chemicals accidents from 2010 to 2014, of which 77% occurred during the transportation. Data statistics found that the hazardous chemicals road transport in China is increasing year by year. It has reached more than 300

million tons in 2015. Moreover, because of the nature of hazardous chemicals.

Once the accident of dangerous goods transport happens, it may result in heavy casualties, economic losses and environmental destruction and pollution. Now most of the domestic dangerous goods logistics enterprises are not well organized, for the relevant laws of hazardous chemicals are also lack of understanding. The imperfect system of laws and regulations as well as the poor supervision of relevant departments also gave the enterprise to make use of the loopholes in law. Of course, because of their own interests, more enterprises still reduce or ignore the safety requirements of hazardous chemicals in the logistics.

### III. RISK IDENTIFICATION OF DOMESTIC HAZARDOUS CHEMICALS ROAD TRANSPORT

Identification of risk factors is the basis of risk control, only in the correct identification of the risks can be targeted to quickly use the appropriate method to control the risk. Risk factors can be identified from several aspects, any small factor can cause an accident. In order to avoid risks, the cause of these accidents should be analyzed and the relevant risk control and safety management should be developed. In this paper, through the collection of 61 major hazardous chemicals road transport accidents information in last 3 years, related literature and news reports in nearly 2 years, from drivers, transport vehicles, chemical categories, management methods and the environment aspects, the method of Fishbone Diagram identifies the influencing factors of the specific road transport of hazardous chemicals and analyzes them.

#### A. Identify the Risk Factors of Domestic Hazardous Chemicals Transport with Fishbone Diagram

The name Fishbone Diagram was given because it looks like a fishbone. It was invented by the Japanese management guru Mr. Ishikawa Kaoru, it is also called Ishikawa Diagram or Cause & Effect Diagram. Fishbone Diagram is a way to explore the bottom cause of the problem. Fishbone Diagram is very simple and practical. In the production, we should draw a trunk bone first and write the subject on the head of the fishbone, then protrude

several large bones on the trunk bone and list the possible causes of the problem, finally, protruding small bones, separately into the causes and marked. In this way, the entire process of risk identification is apprehended at a glance.

Combined with some typical hazardous chemicals road transportation accident cases from 2014 to 2016, gathering and analyzing the illegal investigation of hazardous chemicals in some regions of the country of nearly two years, ultimately making the hazardous chemicals road transportation risk factors Fishbone.

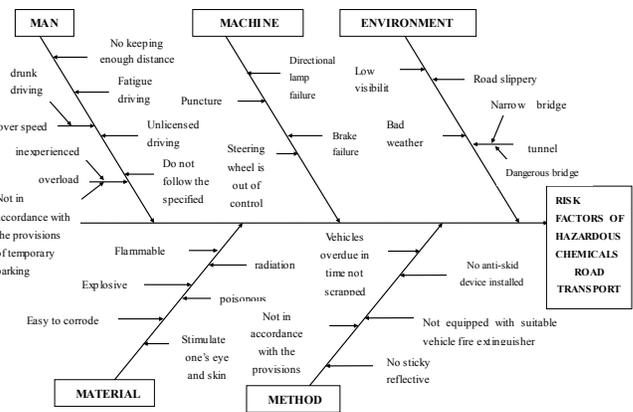


Figure 1. Hazardous Chemicals Road Transportation Risk Factors Fishbone Diagram

#### B. Specific Analysis of Five Risk Factors

##### a) Driver

"People" in this paper mainly means analysis from the driver's point of view. Each driver's personality characteristics are different, and their professional qualities of the transport of hazardous chemicals are also different. According to the relevant examples of hazardous chemicals transportation accidents, it can be found that about 80% of the accidents are caused by traffic accidents, and personnel factors is the main cause of the traffic accidents. If there is no good driving skills and adequate safe driving consciousness, the vehicle equipment and enterprise management system, no matter how good and perfect, are only furnishings. Therefore, enterprises must conduct safety training for drivers, improve their safe driving consciousness and resolutely put an end to speeding,

drunken driving, fatigue driving, illegal parking, not according to the specified route and other common drivers' illegal operations.

*b) Transport Vehicle*

The object of this study is the road transport of hazardous chemicals, so the mechanical equipment mainly involved is the transport vehicle. It can be said that the technical state of the vehicle equipment is also a great influencing factor in the course of the transportation, and whether the safety state and performance of the vehicle are qualified is vital. The most influential part is the car steering and braking system. In a nutshell, it is the steering wheel, deceleration and stop problems. At present, all the hazardous chemicals transport vehicles must be installed and used GPS system and emergency cut-off device, and they are also one of the objects that the traffic police department checks the vehicles conveyed hazardous chemicals. Secondly, the vehicles conveyed hazardous chemicals must be inspected on time, and the overdue vehicles should be scrapped in time.

*c) Classification of Hazardous Chemicals*

The material here is equivalent to the transported object in the road transport of dangerous chemicals - hazardous chemicals, that is, the hazard characteristics of the chemical itself may be the risk of the transport process, and inflammable and explosive goods in nine categories of hazardous chemicals are the main source that caused the accidents in the road transport of dangerous chemicals. For example, on October 30 in 2015 at Jiangxi Xinyu section of the Shanghai-Kunming high-speed, a truck fully loaded with fireworks and firecrackers exploded in the process of driving, causing three fatalities and one serious injury. Fireworks and firecrackers are inflammable and explosive goods. According to the statistics the State Administration of Work Safety statistics published, there were 7 more major accidents caused by fireworks and firecrackers' explosion, and 36 people died nationwide in 2004. Thus it can be seen, the risk of the material itself will greatly increase the risks it brings to enterprises.

*d) Management Method*

The method here refers to the management of the enterprises. As long as there is someone, there is no

guarantee of "Zero" mistake. So only through the enterprises' layers of management and supervision and strengthening the training to enhance people's safety awareness, the failure could be minimized. However, in most cases, the company's business direction is mainly concentrated in reducing costs and improving customer service, so many companies ignore the risk management of transportation safety.

*e) Environment*

The location and traffic conditions of the accidents will affect the arrival and emergency rescue time of the fire and traffic police departments, while uncertain whether factors and the geographical conditions of transportation routes will also affect the probability of such accidents, and there is a great possibility of increasing the severity of the consequences of the accidents. Therefore, in the transportation of dangerous chemicals, the environment is also a great influential risk factor. In this paper, the environmental factors that affect the road-transportation safety of hazardous chemicals mainly refers to the weather and geographical conditions.

#### IV. RISK ASSESSMENT OF DOMESTIC ROAD

##### TRANSPORTATION OF HAZARDOUS CHEMICALS BASED ON RISK MATRIX

The risk matrix is mainly used to identify the risks in project management, to assess the potential risk factors and the probability of risks in the project, to determine the risk level by pre-evaluation criteria, and then to consider risk control to reduce risk. I believe that the management of hazardous chemicals road transport enterprises is also a kind of project management which risks exist. Therefore, the use of the risk matrix to explore the domestic road transportation of hazardous chemicals can be more clear and intuitive to understand the risk level division, in order for the follow research on Risk Control of Transportation Enterprises. This paper first uses the risk matrix to explore the risk control in hazardous chemicals road transportation enterprises.

*A. The Origin and Explanation of Risk Matrix*

In 1995, the US Air Force Electronic Systems Center

systematically presented and widely used risk matrix assessment methods for the first time in the life cycle risk assessment of acquisition projects.

The risk matrix chart, also known as the Risk Matrix, is a qualitative risk assessment method that can estimate the magnitude of risk by synthetically assessing the probability of risk and the dimension of injury. It is a tool for risk visualized that is used primarily for risk assessment.

Instructions:

1. Hazard Identification: lists the dangerous states that need to be assessed;
2. Hazard Determination: Select a hazard level for each dangerous state according to the ruled definition;
3. Damage Estimation: Estimates the likelihood of occurrence for each identified hazard state;
4. Risk Assessment: According to the results of steps 2 and 3, find the corresponding intersection on the matrix, and draw the risk conclusion.

*B. Basic Mathematical Model of Risk Matrix*

The form of the risk matrix can be fixed, and its grading function is described as follows:

$$\text{When } \begin{cases} I_i \leq I < I_{i+1} \\ P_j \leq P < P_{j+1} \end{cases}, R=f(I,P)=[R_{ij}]$$

In this form: I is the risk influence factor, P is the risk probability factor;

$R_{ij}$  represents the risk level in the risk matrix corresponding to the risk level i and the probability of risk level j;  $I_i$  and  $P_j$  respectively represent the lower limit of the i-class risk probability and the j-class risk effects;  $I_{i+1}$  and  $P_{j+1}$  respectively represent the corresponding upper limit.

*C. Establish Risk Consequence Levels and Frequency of Events*

In the risk evaluation, we need to divide the risk consequences into four categories of personal injury, property damage, environmental impact and reputation effects, each category is divided into six levels by the severity of the consequences, according to the accident frequency range the risk possibility from low to high as five grades.

According to “Byelaw governing reporting, investigation and handling of production safety accidents” as well as the experience of the actual accidents that took place with the hazardous chemicals road transport in

previous years. The potential impacts of hazardous chemicals road transport from the personnel, property, environment and reputation are divided into six levels, and the six levels are assigned with 0,1,2,3,4,5,6, and use the assignment data and the potential impact of these four aspects to make Table 1 for the subsequent production of Risk Matrix. As shown in Table 1.

TABLE 1 ESTABLISH RISK CONSEQUENCE LEVELS AND FREQUENCY OF EVENTS

Consequence Severity assignment	Risk consequences			
	personnel	property	surroundings	reputation
0	No harm	No loss	no effect	no effect
1	Mild injury	Slight loss	Slight impact	Slight impact
2	Severe injury	Moderate loss	Moderate impact	Limited impact
3	1 People die	Local loss	Local influence	Local influence
4	2-3 people die	huge loss	Tremendous influence	Domestic impact
5	> 3 people die	Great loss	great influence	International influence

Reference to the consequences of domestic hazardous chemicals road transport accidents in last 10 years in accordance with the target event frequency are divided into five levels, each level were made the following definition:

- A - Rarely (once every ten years)
- B - Occasionally (every five years)
- C - Possible (every three years to five years)
- D - Sometimes (every year to three years)
- E - Often (more than once a year)

For the convenience of calculation, simply assign A, B, C, D, E these five levels assigned to 1, 2,3,4,5, produced as follows:

TABLE 2 ACCIDENT FREQUENCY AND ASSIGNMENT

Assignment	1	2	3	4	5
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frequency	rarely	occasionally	possible	sometimes	often
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**D. Risk Matrix Model for Domestic Hazardous Chemicals Road Transport**

After setting the risk consequences and the risk frequency, using the seriousness of the risk consequences as table columns and the severity of the risk as table rows to made into a table. According to the data given, the risk is

calculated according to the following formula:

$$\text{Accidents Risk Factors} = \text{consequence severity level} \times \text{frequency of occurrence}$$

The calculated values are filled into the intersection of the ranks, all the values constitute a matrix and finally the value of the risk classification according to the results shown in Table 3.

**TABLE 3 RISK MATRIX OF DOMESTIC HAZARDOUS CHEMICALS ROAD TRANSPORT**

Risk matrix	General risk		Significant risk			Assignment	Risk consequences			
	5	10	15	20	25		Personnel	Property	Surroundings	reputation
General risk	5	10	15	20	25	5	More than 3 people died	Great loss	great influence	International influence
	4	8	12	16	20	4	2-3 people died	huge loss	Tremendous influence	Domestic impact
	3	6	9	12	15	3	1 person died	Local loss	Local influence	Local influence
low risk	2	4	6	8	10	2	Severe injury	Moderate loss	Moderate impact	Limited impact
	1	2	3	4	5	1	Mild injury	Slight loss	Slight impact	Slight impact
	0	0	0	0	0	0	No harm	No loss	no effect	no effect
Assignment	1	2	3	4	5					
frequency	V	O	M	S	F					

V: very; O: occasionally; M: May; S: sometimes; F: often

The color zone of Figure 2 is the risk level divided by the value of the risk factor. This paper refers to the attachment of judgment criteria of Safety Risk Classification Control (LS) in “The Implementation Guide of the Risk Classification Management for Chemical Enterprises Safety(Trial Version)” as well as the statistics of actual accident consequences in hazardous chemicals roads transport roughly divided the risk level into three aspects, the specific situation as shown in Table 4.

**TABLE 4 CLASSIFICATION OF RISK LEVELS**

Risk value	Risk level	Remarks
12-25	Significant risk	level III
3-10	General risk	level II
0-2	low risk	level I

The risk level is classified as low risk zone, the general risk zone and the significant risk zone, separately assigned level I, level II and level III.

### *E. Hazardous Chemicals Road Transport Risk Factors Control*

Combined with the risk factors for the hazardous chemicals road transport in Figure 1, the following evaluation objectives are listed. According to the 61 cases of hazardous chemicals road transport accidents collected to define the consequences level and the statistics of the

accident rate, with the formula:

$$R=I*P$$

To calculate. In this formula: R: accident risk factor; I: accident impact factor; P: accident probability factor.

The risk factor calculated from the above formula is then divided according to Table 4 for the risk level, get the following table:

TABLE 5 RISK LEVEL OF THE TARGET EVENT

Evaluation target	Consequence severity level	occurrence frequency	Risk factor	Risk level
Speeding	5	4	20	III
Overload	4	4	16	III
Fatigue driving	2	2	4	II
Drunk driving	4	1	4	II
Insufficient driver experience	2	1	2	I
No keeping enough distance	3	3	9	II
Do not follow the driving route	2	2	4	II
Puncture	2	1	2	I
Steering wheel is out of control	3	1	3	II
Brake failure	4	1	4	II
Directional lamp failure	2	1	2	I
Low visibility	2	2	4	II
Road slippery	2	2	4	II
Bad weather	2	2	4	II
tunnel	2	2	4	II
Sharp bend	3	3	9	II

From the above table can be drawn that speeding and overload is the most important risk factors in hazardous chemicals road transport and it is also unacceptable. Hazardous chemicals transport enterprises need to rectify and control the risk immediately. Secondly, the drivers' fatigue driving, drunk driving, not keeping enough distance, not driving on the route, the steering wheel in the vehicle equipment is out of control, the brake failure in the personnel factor and environmental factors of low visibility, bad weather, road slippery, tunnel And the sharp break is a general risk, is in the case of business costs allowed, the need to develop measures to reduce the risk. Finally, due to lack of experience in drivers, the vehicle puncture, the

direction of light failure caused by the lower level of risk, companies can suspend rectification and through the daily management to continue to improve.

## **V. SUGGESTIONS AND MEASURES FOR RISK MANAGEMENT OF DOMESTIC DANGEROUS GOODS TRANSPORTATION**

### *A. Strengthen the Professional Training of Employees*

For dangerous goods road transport, safe must be put in the first place. Because of the nature of the chemical, the transport of hazardous chemicals vehicles in the event of a traffic accident or improper operation in the transport process, is likely to cause major traffic accidents, or adverse

environmental impact. According to the statistics of road transport accidents in previous years, we can see that hazardous vehicles are the most frequent, the main reason for this is the occurrence of traffic accidents.

*a) From the Driver's Point Of View*

Whether through the analysis of the accident over the past three years or the risk matrix of the hazardous chemicals road transport enterprises, we can see that personnel are the most important factors leading to the accident. Many dangerous chemicals transport drivers lack the necessary dangerous chemical safety knowledge, in case of emergency cannot be timely and effective disposal, which may lead to more serious accidents. Enterprises can arrange for professionals to conduct lectures and training regularly on the driver, watch the relevant incident video and understand the relevant information statistics, you can also establish a safety training base, which can carry out the simulation of the accident, let the drivers familiar with the rescue steps after the accident. More importantly, not only to let the driver understand the safety of transport chemicals common sense, but also let the driver understand the importance of safe driving, do preventive driving.

*b) From the Perspective of Business Executives*

It is not enough for the driver to do safe driving, because it need the manager does the preparation of the driver before driving the car as a prerequisite, including vehicle inspection, chemical packaging, route planning, etc., and strictly prohibited overload overrun behavior. In transport, the management of the enterprise cannot be relaxed, the monitoring center should be aware of the high risk of hazardous chemicals transport supervising of traffic conditions, driver driving situation, reminding the driver promptly through the GPS voice, to prevent fatigue driving and speeding. For the safety training of managers, for the leading cadres at all levels, mainly to implement laws and regulations, strengthen safety awareness, increase safety knowledge as the main content; direct management personnel to implement the sense of responsibility, master the safety management methods, enhance safety skills as the main content.

*B. Strengthen Law Enforcement Supervision, To Prevent Illegal Acts*

Traffic control departments should strengthen the law enforcement, and transport, safety supervision departments jointly management, banning the transport of dangerous chemicals do not have the right to carry out illegal transport behavior of enterprises, severely punish illegal vehicles, tanks, illegal crime, thorough investigation of no effective hazardous chemicals Transport licenses, driving licenses and driving permits, as well as other driving drivers and escorts, to try to eliminate all possible dangers on the road. At the same time, law enforcement agencies should also increase the intensity of the order of the transport of dangerous chemicals, thorough investigation does not follow the provisions of line travel, speeding, fatigue driving, along the illegal handling of dangerous chemicals and other illegal acts.

*C. Departments to Monitor, Improve Laws and Regulations*

As China's dangerous goods road transport management of government out of the door, leading to business difficulties, cross-functional departments led to the phenomenon of uncoordinated management occurred, inefficient management. Therefore, to do a good job of domestic dangerous chemicals road transport enterprise risk control first through the support of the government to strengthen leadership, so that all regulatory departments can work closely together and co-management. Second, we need to improve the laws and regulations, to solve the embarrassing situation of government and more, as soon as possible to plan with the international standards, applicability, comprehensive and unified laws and regulations, so that dangerous chemicals road transport enterprises have clear legal rules and regulations.

*D. Improve the Information Construction, Achieve Resource Sharing*

Hazardous chemicals road transport needs security assurance, with advanced information technology and strict scientific management, this must be through the network technology to establish an information platform, In order to enable the management of enterprises in the process of

monitoring the entire road transport, and always ensure the smoothness of transport and cargo safety. So that we can further improve the level of scientific management of enterprises in the entire dangerous chemicals road transport process to achieve foolproof.

#### VI. CONCLUSION

With the increasing demand for products at home and abroad, in view of the development prospects of hazardous chemicals logistics, we should also know it takes transport enterprises a great risk. Based on the actual case of road transport in the past, this paper aims at some problems in the risk control of domestic dangerous chemicals road transport enterprises, using the fish bone map to identify the risk factors, and then build a risk matrix, and the use of actual cases to analyze the case of its control measures, not only provide a theoretical and technical support for the risk management and control of the dangerous chemicals road transport enterprises, but also help other industries to identify and evaluate the risk of road transport of hazardous chemicals.

I hope that the government, chemical enterprises, related logistics and transport enterprises pay attention to take appropriate measures to the safety of hazardous chemicals road transport, understanding the risks in transport, doing a good job in accident prevention and emergency measures, doing a good job of dangerous chemicals road transport risk control.

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