

Applications of Cross-Track Theory to Control Accidents of the Transport of Mountain Dangerous Goods

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Abstract: For the purposes of the characteristics of mountain road transport of dangerous goods, identified risk factors of accidents on mountain road transport of dangerous goods by using the system theory of "human-machine-environment", established safety index system of mountain road transport of dangerous goods, found out the track of the passenger and cargo flow of an accident, decomposition of this point, found out risk factors, determined the weight of risk factors by using functional theory, sort the risk factors. In practice transportation, the main factors can be controlled would be used to avoid accidents. This study of the paper has practical significance to avoid mountain transport accident of dangerous goods.

Keywords: crossover theory; cargo transportation; functional theory

1 Introduction

Crossover theory is an accident causation theory, the basic idea is: Injuria is a result formed by many interrelated sequence development of events. In this paper, "human-machine-environment" system is used to identify risk factors of dangerous goods transport accidents on mountain. Under certain environmental conditions, when the unsafe acts of human and unsafe state of things in their own development process, take place crossover occurs at a certain time or space, the accident occurred; If prior to the accident, unsafe acts of human or unsafe state of things are changed, the accident would not have happened. Therefore, it is important that the main factors of unsafe acts or unsafe state are controlled. In controlling the mountain transport accident of dangerous goods, humans mainly include the secretary for passengers, goods mainly include vehicles and dangerous goods, this paper is as an example of the explosive goods for analysis.

2 Risk Analyses on Mountain Transport of Dangerous Goods

Mountain road transport of dangerous goods varies greatly with the plain areas, mountainous road downhill, turning more, and the distance is longer. When explosive goods are transported in the mountains, the main consideration includes the unsafe acts of human and unsafe state of things (vehicles safety, risk of dangerous goods) and environmental risk analysis.

2.1 Analysis on Unsafe Acts of Human

Unsafe acts of human mainly include the division staff's physiological, mental and physical birth defects, mental defects, illegal driving, behavior errors and other factors.

2.2 Analysis on Unsafe State of Things

1 Vehicle safety analysis

When dangerous goods are transported in the mountains, the vehicle performance is particularly important, the safety of vehicles must be considered to control accidents.

1) The braking system failed: when the vehicle's braking system must be reliable, effective, growing up in downhill in the mountains or sharp turns. If the braking system failed, vehicles are easy to fall into the cliff, or explosive goods produced explosion dangerous as the impact.

2) The lighting system failed: mountain is easier to produce rain and fog weather, especially in winter. When the climate is in the rain and fog or at night driving, the vehicle lighting system failed, resulting in field of vision, prone to accidents such as rear-end collision or explosion.

3) Mechanical error: When the vehicle is during driving process, due to a long road, maintenance is not timely, with impaired driving and other reasons, the key mechanical components are prone to be damaged, in severe cases the vehicles can be forced to stop in half-way.

2 Risk analyses of dangerous goods

This paper would analyze risk of explosive goods, for example.

1) Thermal effect: Explosives are heated and redox reaction occurs, as well as produce an explosion.

2) Mechanical action: The impact of friction, intense mechanical action is likely to cause an explosion.

3) Photo-thermal effect: Sunlight or other source of heat radiation, which may cause explosive heat. Sunlight in the ultraviolet can promote chemical reactions.

4) Metal effect: Picric acid in a relatively high humidity, with iron, zinc, aluminum and other metal

contact, the generated very unstable picrate, this salt is very easy to react by the mechanical action.

5) Acid effect: Strong acid and picric acid, smokeless powder and other violent reaction took place a lot of heat, causing an explosion.

6) Other factors: Shock waves, blast waves, electricity and nuclear radiation, also could lead to the explosion possibility.

3 Packaging conditions

Because of the sensitivity, brisance and other features of explosives, the packaging of explosives has special requirements. The packaging good types of explosives are in accordance with nature of the goods, have a certain intensity, and should be able to withstand the diversification of temperature and humidity within a certain range.

2.3 Analysis of Environmental Risk

1 Road risk

The road design is unreasonable, signs, markings are not clear, view of the road is not open, roads in disrepair for years, these factors are easy to lead to the transport accidents.

2 Natural risk

1) Impact of high-temperature environmental

In the conditions of transport of dangerous goods, the concepts of ignition, melting point, self-ignition point, boiling point, flash point, flash point are used, because the temperature for the vast majority of dangerous goods has a direct impact.

During the hot summer, strong solar radiation, combined with the bumps, collisions in the transportation process will face the terrible burning, explosion, and the consequences are unimaginable. In addition, the fire environment, explosive goods generated heat, then the possibility of fire, explosion accidents is even greater.

2) Lightning effects

a) Electrostatic induction

In terms of the transport of dangerous goods, if their internal metal framework, metal utensils but bad ground,

then it is easy to produce sparks, which is quite dangerous for the transport vehicle.

b) Electromagnetic induction

As the lightning current has great peaks and steep degrees, the space around it has a strong change in electromagnetic field, in which the conductor will be a larger electromotive force induced. This induced Emf make metal ring gap discharge sparks, or make poor contact of the metal circuit overheating, explosives are tend to be explosive.

c) The introduction of high-voltage lightning strike

Lightning directly stroke or lightning induction from power lines, communication cables and other metal lines of the introduction of the vehicle can cause Lightning disasters and accidents.

3) Influence of rain and snow weather

Some dangerous goods can not contact with water, such as calcium carbide and so on, when the rain and snow leaking into the packaging, flammable goods react with water, the risk increases. Therefore, in the transport of flammable goods, the packaging is particularly important.

3 The social environment risks

If the safety awareness of the local population is not high, or do not understand the dangerous nature of the goods, cargo theft and accidents will take place.

3 Transports of Dangerous Goods Accidents on Crossover Analysis

Through the preceding analysis we can see that risk factors of mountain transport of dangerous goods can be divided into the unsafe acts of human and unsafe state of things and environmental risk factors and so on. Environmental risks promote human, and things unsafe factors, in the case of adverse environmental conditions can promote the occurrence of the accident. Accident was the contact points between the unsafe factors of human and things. This paper applied functional theory to filter out the unsafe factors of human and things, found out the major risk factors.

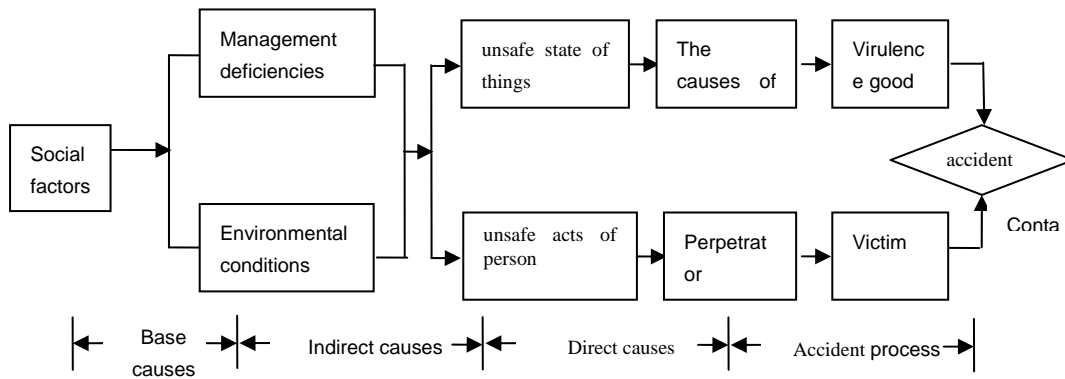


Figure 1. Accident model of tracks crossing theory

4 Using Functional Theory to Determine the Weight of Affect Factors

4.1 Functional Theory

1 Standardize space of indicators

Layer includes 10 basic indicators, it is taken into account that the Hilbert space has a good character of number-multiplication, it needs to establish a ten-dimensional Hilbert indicators space H10, each of its one-dimensional space corresponds to one indicator of assessment.

On the assumption that $i=(i_1, i_2, \dots, i_{10})$ is a set of standard orthogonal basis of H10, indicators vector Z is the distribution of original indicators in H10, vector T is

a space after every index weight considered. The indicator vector Z can be expressed as:

$$Z = \lambda_1 i_1 + \lambda_2 i_2 + \dots + \lambda_{10} i_{10} \tag{1}$$

And the existence of mapping ∇ (weight vector) could make the following equation set up:

$$T = \nabla Z = \nabla_1 \lambda_1 i_1 + \nabla_2 \lambda_2 i_2 + \dots + \nabla_{10} \lambda_{10} i_{10} \tag{2}$$

2 Determine the weight of indicators layer

The weight which every indicator relates to criteria layer is determined by fuzzy assessment method, specific method refers to literature. The weight of factor of indicator layer relates to factor of criteria layer which is determined ultimately as follows:

$$\nabla_n = c_k p_{kj} \quad n = 1, 2, \dots, 10 \tag{3}$$

Table 1. Safety situation assessment form of dangerous goods transport

Target layer	Safety situation of dangerous goods transport (T)									
Criteria layer	Human factors (A)			Physical factors (B)				Environmental factors (C)		
Indicators layer	Physiological factors	Psychological factors	Behavioral factors	Illegal driving	Vehicle status	State of dangerous goods	Packaging conditions	Natural environment	Road environment	Social environment
Code of underlying indicators	A ₁	A ₂	A ₃	A ₄	B ₁	B ₂	B ₃	C ₁	C ₂	C ₃
Value of underlying indicators	0.04	0.06	0.36	0.54	0.20	0.42	0.38	0.25	0.55	0.20
Value of indicators of criteria layer	0.43			0.35				0.22		

Note: The underlying indicators value is initial data, which is root in the coalescent of functional theory and the weight which experts score.

4.2 The Comprehensive Indicators of the Accident Impact Factors

From the above table we can see, driving illegally factor is the most important among the human factors, the state of dangerous chemicals, and packaging conditions appear to be more important among all thing factors, among environmental conditions, the road condition is more important among environmental factors. In "human-machine-environment" system, the dominant human factors. Due to limited space, this paper doesn't determine the index weight of more detailed layer.

5 Conclusions

1) To analyze transport risk of dangerous goods through the mountain, transport enterprises can refer to the influencing factors of dangerous goods, to understand risk factors; environmental conditions are led into cross-track, environmental risk factors can promote the accident effect;

2) The weight that indicators layer relate to criteria layer is calculated by using of functional theory, the method comprehensively uses several kinds of assessment methods and analysis methods to minimize the impact of subjective factors, makes assessment conclusion more scientific, practical and convenient;

3) If the main factors of unsafe factors of human and thing can be controlled, the probability of the accident occurrence will be greatly reduced, the reducing extent of the probability to be further studied.

References

[1] GUO Zizheng, TANG Youhua. Safety Evaluation Model for the On-Duty Operation of Single Locomotive Driver[J]. China Railway Ailway Science, 2008, 29(1): 107-113.
 [2] Jiang Zejun. Fuzzy Mathematics Tutorial[M]. Beijing: National Defense Industry Press, 2003.
 [3] Long Shengzhao, Huang Duan-sheng, Chen Daomu, et al. theory and application base on man-machine-environment system engineering. [M]. Beijing: Science Press, 2004.