

Application of Index System Method in Optimization of Third-Party Safety Inspection Service in Transportation Industry

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Abstract. Potential accidents in the transport industry are prominent, and major risks have not been resolved. In particular, with the advent of the post-COVID-19 era and the development of the national economy, the transport industry will face greater pressure on production safety. Through the basic investigation of many transportation enterprises, such as road transportation, ports, water transportation, and construction projects, this paper uses the index system method to describe the overall situation of the industry, and obtains different weight coefficients and scores, and calculates them to obtain the comprehensive safety level. Based on this, the paper summarizes the main problems in enterprises and industry safety supervision. The safety supervision system of transportation industry is facing profound changes. And the introduction of third-party security services helps to improve the safety supervision chain. This paper compares the history of the development of third-party safety inspection services, analyzes the problems of third-party safety inspection services in the transportation industry, and puts forward ideas on the construction of the third-party safety inspection mechanism from the aspects of work content, work flow and work content. It will help prevent and defuse major safety risks in the transportation industry and promote the sustainable, steady and sound development of the transportation industry.

Keywords-Transportation Industry, Third-Party Inspection, Security Risk, Mechanism, Safe Production

1. Introduction

With the sustained and rapid development of the economy, people's demand for transportation keeps increasing, the total number of accidents in the transport industry shows a downward trend, but the frequent occurrence of major accidents has not been fundamentally curbed. In recent years, the accidents have occurred frequently in China's transportation industry system, which has caused serious losses to the people's lives and property, such as Wenling “6.13” LPG tank car explosion accident, Wuxi “9.28” serious road traffic accident and Nanchang “1.8” road traffic accident.

How to effectively reduce the safety accidents and curb the occurrence of major accidents requires the government to innovate the methods of safety supervision and explore the implementation of a new model of third-party social services. On the basis of clarifying the

connotation of safety production in the transportation industry, this paper determines the evaluation indicators from three aspects: target layer, rule layer, and index layer; then, the weight coefficient and score are calculated based on the investigation results, and the comprehensive safety level is finally obtained. Combined with the quantitative risk, the outstanding problems in the industry are analyzed pertinently, and the technical service system of third-party safety inspection is proposed to provide reference for improving the safety level of the transportation industry.

2. Development status of third-party safety inspection

Safety production is a major issue related to the safety of people's lives and property, and is a requirement for the stable and healthy development of the economy and society. The Central Committee of the CPC and the State Council have always attached great importance to work safety. Especially since the 18th CPC National Congress, General Secretary Xi Jinping, who is the General Secretary of the Central Committee of the Communist Party of China, planned to promote the development of production safety at the height of governance, put forward a series of new ideas, new thinking and new strategies for work safety. Xi pointed out that life is more important than Mount Tai. Party committees and governments at all levels must put safety production in an important position and firmly establish the concept of safety development. We should strengthen the management of safety production in key areas such as transportation, fire protection and hazardous chemicals, and curb the occurrence of particularly serious accidents.

At present, the work of safety production in our country implements the principle that "managing industry must manage safety, managing business must manage safety, and managing production and operation must manage safety", strengthen and implement the principal responsibilities of enterprises and the regulatory responsibilities of the government. In 2017, the CPC Central Committee and the State Council issued "the Opinions on Promoting the Reform and Development of Work Safety". It was pointed out that "the professional technical service of production safety should be brought into the development plan of modern service industry, diversified service subjects should be cultivated, and the system of government purchasing, production safety service should be established". The document provides policy support for government procurement of third-party safety consulting services. Since then, third-party safety services have emerged as a new form of service. At present, the more common service methods include third-party safety inspection and safety consultants [1].

In recent years, the development of the transportation industry has been significantly impacted by the COVID-19 epidemic. With the introduction of a series of optimization measures, such as the "Ten New Measures" for epidemic prevention and control under the Joint Prevention and Control Mechanism of The State Council, the transportation industry begins to accelerate its recovery, which brings new requirements and challenges to production safety. Under the new situation, how to give full play to the technological advantages of third-party safety services to improve the ability of safety risk prevention and control ability and safety development of the transportation industry have become an important research.

3. Current situation of safety production in transportation industry

3.1. Safety risk level of transportation industry

In order to objectively grasp the real safety production level of the transportation industry and quantify the overall safety risk level, the research team selected 200 enterprises from the key areas of transportation industry to carry out the survey, such as road transportation, ports, water transportation, and construction projects. It is focus on these aspects, including qualification conditions, safety production responsibility system, safety management system, education and training, safety investment, emergency management, safety risk hierarchical control and hidden danger investigation and treatment, and accident report and treatment. According to the characteristics of safety production in the transportation industry, this paper uses the index system method to describe the overall situation of the industry, and obtains different weight coefficients and scores, and calculates them to obtain the comprehensive safety level.

First of all, the project team will determine the grading range of the indicators according to the actual survey and grading of 200 enterprises, then, within the score range of the grading interval, use interpolation method and other methods to collectively discuss and determine the score of the index. When determining the grading range of the index, follow the most unfavorable principle, and the more unfavorable the case, the greater the value. The weight coefficient is used to distinguish the importance of each evaluation index.

According to the correlation between the evaluation indicators and the probability of accident occurrence and the severity of accident consequences, the evaluation indicators are ranked in order of importance from high to low. The weight coefficient calculation formula is as follows:

$$\gamma = \frac{2n - 2m + 1}{n^2} \quad (1)$$

In the model: γ -weight coefficient; n -number of terms; m -importance sequence number, $m \leq n$.

owing formula:

$$F = \sum X_{ij} \quad (2)$$

$$X_{ij} = R_{ij} \gamma_{ij} \quad (3)$$

In the model: X_{ij} -score of evaluation index, $i=1、2、3$, $j=1、2、\dots、n$, n is the number of evaluation indicators included in the corresponding item i .

After calculating F , the safety risk level of transportation industry is determined according to table 1.

Table 1. Safety risk classification standard

Safety risk	F
IV (Major risk)	$F \geq 60$
III (Higher risk)	$60 > F \geq 50$
II (General risk)	$50 > F \geq 40$
I (Less risk)	$F < 40$

Based on the actual situation, this paper assigns and calculates the safety risk level of the transportation industry, the results are shown in table 2 [8-10].

Table 2. Value of safety risk level in transportation industry

Target layer	Rule layer	Index layer	Basic score (R_{ij})		Weight coefficient (γ_{ij})
			Score	Value	
Qualification conditions X_1	Enterprise qualification X_{11}	The actual operation goods are not consistent with the scope of business, and there are situations such as unauthorized or beyond the scope of permission	75~100	25 (R_{11})	0.21 (γ_{11})
		The name and address in the permit do not consistent with the business license	50~75		
		Expiration of business license and business license	25~50		
		Both the business license and business license are valid	0~25		
	Personnel qualification X_{12}	The main responsible person and the safety engineers have not obtained the safety assessment certificate	75~100	20 (R_{12})	0.03 (γ_{12})
		The main responsible person has not obtained or the safety engineers have not obtained the safety assessment certificate	50~75		
Some safety engineers have not obtained safety assessment certificate		0~50			
Safety management X_2	Safety production responsibility system X_{21}	The content of the responsibility system is seriously missing, or the assessment is not carried out	75~100	70 (R_{21})	0.19 (γ_{21})
		Part of the responsibility system is missing	50~75		
		The content is basically clear, and the proportion of assessment implementation is more than 90%	0~50		
	Safety management system X_{22}	The system is seriously lacking, or the proportion of system not implemented is more than 20%	75~100	70 (R_{22})	0.16 (γ_{22})
		The proportion of partial lack of system or incomplete implementation of system is between 10-20%	50~75		
		The system is basically sound and the implementation ratio is more than 90%	0~50		
	Education and training X_{23}	The education and training system has not been established or implemented	75~100	60 (R_{23})	0.14 (γ_{23})
		Inadequate implementation of education and training system	25~75		
		The education and training system is complete and well implemented	0~25		
	Dual prevention mechanism X_{24}	No dual prevention mechanism has been established, or there are major potential accidents but no effective measures have	75~100	50 (R_{24})	0.11 (γ_{24})

Target layer	Rule layer	Index layer	Basic score (R _{ij})		Weight coefficient (γ _{ij})	
			Score	Value		
Accident and emergency management X ₃		been taken)		
		There are significant risks, but they are not effectively identified or controlled	50~75			
		There are major defects in the dual prevention mechanism	25~50			
		Dual prevention mechanism is relatively complete	0~25			
	Safety input X ₂₅	The system of withdrawal and use of safety expenses is not implemented	75~100	45 (R ₂₅))	0.09 (γ ₂₅)
		Some safety production costs are used beyond the specified scope	25~75			
		The use of safety production expenses complies with national regulations	0~25			
	Contingency management X ₃₁	No emergency plan has been prepared or emergency drill has not been organized	75~100	60 (R ₃₁))	0.06 (γ ₃₁)
		There are obvious omissions in the emergency plan, or the number of emergency drills is obviously low	50~75			
		The emergency plan is incomplete or the number of emergency drills is insufficient	25~50			
		The emergency plan is complete and the drill can be carried out as planned	0~25			
	Accident management X ₃₂	Failure to establish accident management system	75~100	40 (R ₃₂))	0.01 (γ ₃₂)
The accident management system has been established, but the accident and event files have not been established and the relevant personnel have not been educated		50~75				
The accident management system has been established, but the accident and event files have not been established, or the relevant personnel have not been educated		25~50				
The accident/incident file is complete		0~25				
Total					52.3	

It can be seen from table 2 that the evaluation value of the safety risk level of the transportation industry is 52.3. According to table 1, it can be determined that the safety risk level of the transportation industry is relatively high. Transportation is characterized by many points, long lines, wide, range, openness, diversification and complexity of participants. The level of safety in the transportation industry is uneven, all kinds of potential accidents are prominent, existing risks have not been fully resolved, incremental risks are still emerging, traditional risks and emerging risks are intertwined, and the prevention and control of safety risks are increasingly difficult.

3.2. Prominent problems of enterprises in transportation industry

Through sorting out and summarizing the problems found by self-inspection of enterprises in the field of transport, special inspection of managing departments and third-party safety inspection, it is found that the prominent problems in production safety of enterprises in the transportation industry includes following aspects:

3.2.1. Insufficient awareness of the importance of safety management

Enterprises generally have the problem of valuing operation over management. They do not fully understand the importance of safety management, do not have a high position and demand in the safety management work. This has led to a series of problems, such as inadequate implementation of enterprise safety measures, inadequate safety risk management and control, and incomplete inspection and treatment of hidden dangers. In addition, the safety management ability of the enterprise personnel is insufficient. The main responsible person and the full-time safety engineers of the enterprise do not clear about the safety production responsibilities of their posts, and even not aware of the importance of safety management.

3.2.2. Safety management system construction and implementation is not thorough

Firstly, the actual operation of many enterprises is inconsistent with the system. The safety management system formulated by the enterprises fails to provide relevant guidance for the operation and fails to implement. Secondly, there are contradictions in the content of the system formulated by some enterprises, resulting the safety management cannot really be implemented. Thirdly, the content of the system has not been updated and adjusted according to the new laws and regulations and the actual operation of the enterprise. At last, the safety management system of many enterprises is commissioned by third-party service agencies. Due to the low participation of enterprises and the lack of professional knowledge and ability of third-party service agencies, the safety management system is not standardized enough.

3.2.3. The production safety responsibility system is not sound

Firstly, some enterprises have not established a safety production responsibility system. Secondly, the production safety responsibility system does not achieve full coverage, the main existing problems include production safety responsibilities do not comprehensive, job responsibilities do not specify the responsible personnel and the scope. The personnel safety production responsibility book is inconsistent with the production safety responsibility system. Thirdly, some enterprises have not formulated assessment methods for safety production responsibility system. At last, the safety production responsibility system has not been decomposed to specific posts, the content of the responsibility system has not included all the work of enterprise operation, and the system construction is not perfect.

3.2.4. The use of safety production funds is not standardized

Firstly, the safety production expenditure of the enterprise is unreasonable, and some contents that do not belong to safety production are included. Secondly, the expenditure records are incomplete, and some enterprises have not put the payment vouchers into the safety production fund management account, resulting in the authenticity cannot be verified. At last, there is a lack of standardized processes for fund expenditure, some enterprises lack the documents for the use and distribution of safety production funds, and the fund records are not standardized.

3.2.5. The guidance of safety operation regulations is not strong

Firstly, some enterprises are not aware of the importance of formulating safe production operation procedures and even have not established safe operation procedures. Secondly, the

content of safety production operation procedures do not combine with the actual situation of the enterprise and fails to provide real guidance for enterprise production. At last, the enterprise does not update the safety production operation procedures according to the actual operation situation, resulting in the actual operation mainly depends on the experience of the personnel and the cognition of the equipment, which has certain potential safety hazards.

3.2.6. The dual prevention system of risk control and safety hazards detection is not perfect

Firstly, some enterprises, especially those in the field of road general goods, have not established a dual prevention system of risk hierarchical control and safety hazards investigation and treatment. They do not aware of the risks and hidden dangers, and do not familiar with the process of risk hierarchical control. Secondly, the enterprise's risk classification standard and actual classification do not consistent with the system content, so it can't be used effectively. At last, some enterprises' safety hazards are not properly identified and eliminated.

3.3. Outstanding problems in safety supervision of transportation industry

3.3.1. The industry safety supervision and management ability needs to be improved

Firstly, the basic professional ability of some industry management personnel does not sufficient. According to the investigation, due to the impact of institutional reform, many law enforcement center teams are composed of non-traffic safety management person. They lack professional knowledge of safety production, and do not familiar with the process of safety inspection. Therefore, there are some problems, such as the safety inspection is not comprehensive and thorough, and often stay in the form. Secondly, the management department does not carry out in-depth inspection on enterprises. In some places, the safety inspection of enterprises is only limited to whether the enterprises have relevant contents, and do not pay attention to the actual situation of the enterprise's safety work. In particular, there is no in-depth inspection on whether the key contents such as the safety management system, risk control and safety hazards troubleshooting and governance, the implementation of safety production funds, and the formulation and exercise of emergency plans are in place. At last, the working concept of industry managers needs to be changed. Some management departments inspected for the purpose of completing the task, and have insufficient understanding of the importance of safety inspection, resulting in the purpose of inspection is just for finish the work.

3.3.2. Relevant documents of safety supervision and inspection need to be standardized

Not only do some management departments mainly rely on their own experience and ability to obtain the documents which used for the safety supervision and random inspection of enterprises, resulting in incomplete collection of documents, but also, their understanding of relevant documents is not thorough, which makes it difficult to find problems during inspection.

3.3.3. Management department's training for enterprises needs to be strengthened

Through investigation, it is found that some management departments do not pay enough attention to the safety education and training of enterprises, and safety training for enterprises is never organized. So the problems always to be solved by experience, and may cause new problems, such as incorrect and incomplete solutions, especially for the enterprise leaders and safety managers of transport of dangerous goods enterprises and passenger transportation enterprises.. The enterprises are not clear about the work requirements and priorities of the management department, which is not conducive to the improvement of its safety management quality.

4. Exploration and development of third-party safety inspection in transportation industry

4.1. Advantage

Local governments have explored the work of third-party safety inspection in order to effectively prevent and resolve major risks and hidden dangers in production safety in the field of transportation, so as to achieve safe production [2]. For example, in 2013, the third-party inspection team entrusted by the Port Bureau of Jiangsu Provincial Department of Transport, carry out professional safety spot inspections of ports along the Yangtze River. The scope of sampling inspection included 15 port dangerous goods operation enterprises and 9 local port administrative departments. In this inspection activity, 370 safety hazards were found, and 15 notices of safety hazards rectification were issued. In 2017, Zhoushan City entrusted one third-party professional organization to carry out a comprehensive safety inspection on 48 enterprises dealing in dangerous goods at the city's ports, the inspection team put forward countermeasures for safety hazards, safety supervision levels have been divided for the government carrying out targeted supervision conveniently. In 2017, the Hainan Port and Navigation Administration hired one third-party safety technical agency to assist in safety inspections of dangerous goods enterprises at 12 ports in the province. Through the inspection, 535 safety hazards were found, 4 rectification notices were issued, and 2 enterprises with major safety hazards were shut down.

Through the third-party safety inspection conducted by professional organizations, the safety work in the transportation industry has been vigorously promoted, which has been recognized by management departments and enterprises, and has produced good safety and social benefits. It is mainly reflected in the following four aspects.

- improve the effectiveness of industry regulation

Due to the limited human resources and professional knowledge of the industry management department, it is difficult to thoroughly complete many regulatory tasks. The third-party professional technical service organizations, which has professional advantages and rich experience, can assist the industry management department to supervise and manage, solve the problems and problems in the supervision and management, realize scientific law enforcement, and alleviate the problem of weak strength of the industry management department.

- improve the level of industry regulation

In the process of project development, through the technical experts combining with the actual situation of enterprises to participate in the inspection of law enforcement personnel on-site teaching, government managers can have a clear and intuitive understanding of whether the safety measures are in place. Ultimately, it will improve their operational capacity and enhance the level of law enforcement.

- improve enterprise production safety management

Through the implementation of professional inspection and on-site guidance, the safety skills of relevant personnel can be improved, the awareness of the main responsibility of the enterprise can be strengthened, and the overall safety management level of the enterprise can be improved.

- promote industry-wide awareness of production safety

Through the inspection of the enterprise by the expert team, the high pressure situation can be formed on the production safety and illegal behaviors of the enterprise in the whole industry, so that the enterprise can pay attention to the work of production safety, and further promote the improvement of the production safety awareness of all staff.

4.2. Shortage

Although the work of third-party security services has achieved obvious results, as an emerging form of security services, its working mechanism is still inadequate and systematic, which is mainly reflected in the following aspects [3-5]:

- firstly, the preparation is not enough

Due to the lack of adequate communication and preparation before the implementation of some safety services, the inspection content is not clear, and the key work of supervision is not carried out. Eventually, there will be omissions in the safety inspection, which is difficult to meet the needs of the client.

- then, the service team is not professional

Some security service experts lack business knowledge, do not understand the standard deeply, and do not grasp the safety hazards. It is not conducive to the effective development of security services.

- at last, safety hazards are not completely eliminated

Because the management department doesn't timely follow up the rectification work of safety hazards which checked out by the safety service organization, the enterprise rectification is not active, and safety hazards rectification has not formed a closed loop.

5. Construction of third-party safety inspection mechanism in transportation industry

5.1. Job content

The third-party safety inspection in the transportation industry is usually based on the client's demand. The demand of the management department usually focuses on the inspection of the safety status of the enterprises and timely grasp the production safety trend. Through the

safety inspection of the third-party safety technical agency, Important Hidden Danges are found in time and disposal measures are taken immediately to avoid accidents [6].

The third-party safety inspection usually includes three aspects: Field inspection (general layout, safety facilities, on-site warning signs and the use of individual protective equipment); Ledger inspection (personnel qualification certificates, production safety expenses and the implementation of rules and regulations, etc.); Safety awareness inspection (the safety management personnel's grasp of the safety production situation of the enterprise, the familiarity with the relevant laws and regulations of safety production, and the implementation of safety education and training for employees, etc.).

5.1.1. Production site inspection

It mainly inspects the safety compliance of the equipment and facilities on the production site. Take the port field as an example, including wharf, tank farm (including loading platform), warehouse, storage yard, passenger station, gas station, public auxiliary facilities and equipment, etc.

5.1.2. Operation inspection

It is mainly carried out by observing the on-site operation, inquiring the operators and emergency drills. Emergency drills can be carried out in a random way to test the emergency capability of enterprises without prior preparation.

5.1.3. Document inspection

The inspection generally includes Regulation of safety production management and procedures, education and training, safety investment, equipment and facilities management, safety risk prevention and control, safety hazard inspection and rectification, emergency management, personal protection, accident management, etc. Generally, it can be verified by consulting or random checking of standing books, or by asking, watching video playback or viewing on the spot.

5.1.4. Personnel ability test

The general test objects include the main person in charge of the enterprise, the person in charge of safety, the full-time safety production management personnel, and the operating personnel. The test content usually includes knowledge of laws and regulations, knowledge of safety management, and basic knowledge of the operations.

5.2. Work flow

The operation process of third-party inspection generally includes the establishment of a project team, formulation of the implementation plan, on-site inspection, submission of the safety hazards list and closed loop of safety hazards rectification.

5.2.1. Establishment of project team

The project team usually includes the data collection group, the on-site inspection group, the report preparation group, and the late support group. In addition, it is needed to specify a specific person to act as the liaison. The on-site inspection group should be equipped with

sufficient technical technology. Different types of enterprises should be equipped with corresponding professional experts. If necessary, safety experts can be hired from the public for guidance and help.

5.2.2. Preparation of implementation plan

Formulate a feasible implementation plan according to existing resources and contract agreements.

5.2.3. On-site inspection

On-site inspection and service should be equipped with the necessary tools, such as hard hats, reflective vests, tape measures, vernier calipers, computers, inspection vehicles, etc. When entering the site of the enterprise, the relevant regulations of the enterprise shall be observed and the normal production of the enterprise shall not be disturbed.

5.2.4. Submission of safety hazards list

After research and analysis, the project team should combine with the actual situation of the enterprise, submit a list of hidden dangers, and put forward targeted rectification suggestions.

5.2.5. Closed loop of safety hazards rectification

The enterprise shall formulate rectification plans according to the list of safety hazards and suggestions, clarify the responsibilities of relevant personnel, and carry out effective rectification on schedule. The management department shall track and confirm the rectification.

5.3. Working mode

The third-party safety inspection methods usually include safety checklist method, on-site image evidence collection method, on-site inquiry and discussion method, on-site emergency capability test, etc.

5.3.1. Safety checklist method

Safety check list (SCL) is one of the most basic, simple and widely used system risk assessment methods in system safety engineering, which is used to find all kinds of potential accidents in the system. The object of the analysis is thoroughly analyzed and fully discussed in advance. According to the statistical data of accidents of similar enterprises, the relevant national、local and industrial standards, the safety check list is prepared to find out the possible dangerous and harmful factors and the possibility of accidents in enterprises. and then put forward suggestions for improvement. Professional safety checklist shall be formulated for each field for inspection, including inspection categories, inspection contents, inspection basis, inspection conditions, etc.

5.3.2. On-site image evidence collection method

Take on-site photos of major safety hazards at the inspection site (as shown in Figure 1), conduct safety technical analysis, summary and induction according to relevant national,

industrial and local laws, standards and norms, and identify the location of safety hazards, so as to facilitate enterprises to pay attention to safety hazards and timely rectification.



Figure 1. On-site inspection.



Figure 2. Emergency capability test.

5.3.3. On-site inquiry and discussion method

Production technical experts or relevant professional and technical personnel of the inspected enterprise shall participate in and cooperate with the inspection. Safety production team on the site, targeted to ask the relevant safety management personnel, observe the setting, use, maintenance of safety facilities on the site, and enterprise safety management personnel on the site related safety production issues for discussion and exchange.

5.3.4. On-site emergency capability test

Based on the actual situation of the enterprise, the inspection team selects the prone and dangerous accident types [7], determines the drill subjects on site, and requires the employees of the enterprise to carry out emergency treatment (as shown in Figure 2). According to the drill, the inspection team determines the enterprise's emergency handling ability and effect for emergencies, and understands the daily emergency work status of the enterprise.

6. Conclusion

Potential accidents in the transport industry are prominent, and major risks have not been resolved. In particular, with the advent of the post-COVID-19 era and the development of the national economy, the transport industry will face greater pressure on production safety. By innovating the way of production safety supervision, standardizing the working mechanism of third-party safety inspection and clarifying the work content, it will help prevent and defuse major safety risks in the transportation industry and promote the sustainable, steady and sound development of the transportation industry.

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