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Construction of Safety Performance Management System for Coal Mine Enterprises in China

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Abstract: The bad coal mine natural environment, safety investment deficiency, insufficiency safety performance management system are the main causes leading to the coal mining accident frequently nowadays, building-up safety performance management system is importance to coal enterprises safety work. This paper analyses the security status and the reasons of coal mine enterprises, the important role played by safety performance management system during the course of safe production, and the problems existing in the performance management system. It also puts forward a plan for the establishment of the performance management system in order to create a safe environment for the coal mine enterprises and promote its healthy development.
Keywords: Coal mine enterprise; Safety performance; Performance management system

1. INTRODUCTION

The Eleventh Five-Year plan of Coal industry indicates that coal is China's main energy, the coal industry is the important basic industry which is relationship between energy security and national economy. Coal is the base energy of China's economic development, whether in production or consumption of energy, it always takes 70% share[2]. It provides the impetus and convenient for the national economy and people's lives. Coal industry is a high-risk industry, coal mine production safety situation is grim. Especially in China, the major and serious accidents are frequent, workers are more casualties, which results the great loss in state property and citizens of life and is related to the reform development and social stability.

The results show that: economic development has brought enormous pressure to energy, coal mine ill-being, insufficient safety investment and lack of security performance management system for coal enterprises are the main reason for the frequent coal mine accidents. According to the survey,

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performance management lag affects the degree of safety for the 10.54% (LI Shi-xin, 2008). Coal mine safety performance management system is not only an important safety affect factor, but also a controllable human factor. Establishment of safety performance management system will have great significance to safety production in coal mines.

This paper analyzes the current safety production situation of coal mine in China, probes to those problems in coal mine safety performance management system and proposes a method of building a safety performance management system, which is to promote coal mine safety production.

2. THE CURRENT COAL MINE SAFETY ISSUES AND ITS CAUSE

2.1 China coal mine safety situation is very serious

Table 1 shows the statistics of the number of death, the million tons mortality and the occurrence of major security accidents and particular major accidents in China coal mine each year from 2005 to 2009. In 2005, the number of death in China coal mine was nearly 80% of the world, the number of coal mine accident and death accounted for 26.91% and 40.26% in the number of mining business enterprises accident and death in China. China coal mine accident led to 2,700 deaths in 2009, it was the first time that million tons mortality followed down.

Table 1: The Accident situation in Chinese coal mine enterprises over the years[3]

Year	Death doll	Million tons mortality	Major accident		Particular major accident	
			time	Death toll	time	Death toll
2005	5986	2.81	210	886	11	961
2006	4746	2.04	237	1072	6	233
2007	3784	1.485	15	251	2	61
2008	3092	1.182	28	454	5	174
2009	2700	0.892	7	82	5	363

Source: "China Statistical Yearbook" (2005-2009) and the State Administration of Work Safety Web site

Although the number and mortality of China's coal mine accidents were significantly decreased in recent years, but the number and mortality of coal mine accidents were far more than other countries. In 2008, China coal mine million tons mortality was 1.182 , however, the U.S. coal mine million tons mortality is only 0.027,0.021 and 0.045 respectively in 2004-2006. Figure 1, from 2001 to 2009, the U.S. coal mine million tons mortality is very low and has a very small fluctuation curve; China coal mine million tons mortality is high and is much higher than the U.S. million tons mortality.

[3] National Bureau of Statistics of China, China Statistical Yearbook 2005-2009 Beijing, National Bureau of Statistics Press, 2009.

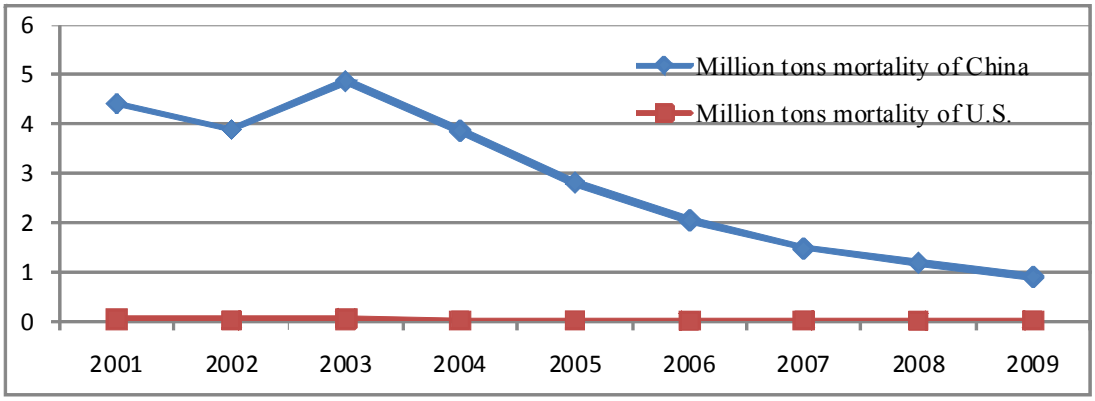

Figure 1: Million tons mortality of China and the U.S. coal mine in 2001-2009

2.2 Analysis of safety problems of China coal mine enterprises

2.2.1 Chinese economic development has brought enormous pressure to energy

Coal is China economics' important energy, sustainable development of China's economy has also increased pressure on energy supplies. In the traditional extensive economic growth mode, expanding the overall economy and the rapid economic development had a huge demand for coal, coal mine enterprises have some pressure on the supply of mine, which leads some coal mine enterprises to ignore security issues in the process of mining.

2.2.2 Backward technology and poor natural environment of China coal mine

China's coal production by underground mining accounts for 95% of total output, the average mining depth of medium-sized coal mines is more than 400 meters, and there are 117 mines whose mining depth is more than 600 meters. And China coal resource is deeply buried, coal is relatively poor stability. Complex geological structure, coal dust, gas, fire, water, roof and other natural disasters factors are more than those of other countries coal mine, the gas emission in high gas coal mine is more than 100 million cubic meters, high gas coal mine accounted for 48% of the world, China is the worst coal mine gas country in the world. With the expansion of the mining scale and the extension of the mining depth, the coal mine production safety is facing greater problems. In the mining process, workers operate in the semi-enclosed space in several hundred meters underground facing with high temperature, humidity, noise, dust, harmful gases such as harsh natural environment, the operating environment is poor, work hour is long, lighting is poor, which are extreme likely to make workers' mood swings produce operational errors and lead to accidents (WEI Gui-lin, 2009).

2.2.3 A serious shortage of safety investment in China coal mine

According to the survey, at present, only state-owned coal mine safety investment default is up to 500 billion yuan in China. 25,000 small coal mines which accounts for 90% of the total, is a congenital lack of investment, its safety investment default is a huge outstanding amount. While coal mining enterprises is lack of adequate investment in staff training and personnel training, vocational skills of workers should be strengthened. Among the current coal mine workers, the middle school or lower education level workers are more than 60%, college and engineering technicians account for less than the total number of 3 %, which account for more than 60% in developed countries.

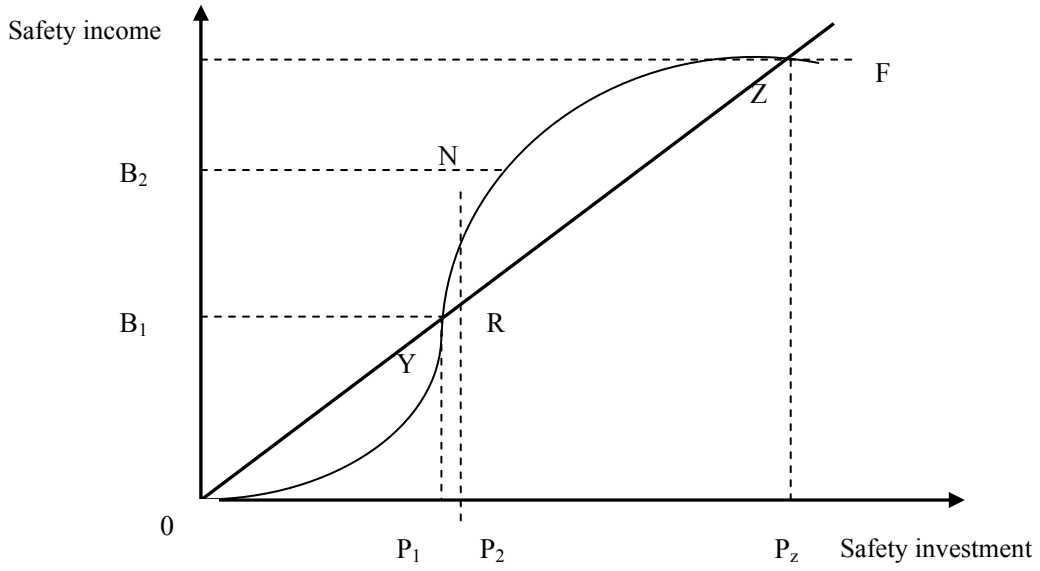

Figure 2: Safety investment - safety income curve

The related study about the economic benefits generated by safety investment by domestic and foreign security experts shows that: the economic benefits generated by the safety investment are several times or even several ten times the invested amount. Therefore, they will regard safety investment as an important means of raising the level of safety production and the creation of economic benefits, and put forward some policy recommendations that enterprises should emphasize and give a reasonable safety investment. According to the principle that the basic economic safety investment objective is to make maximum net income by American scholar Votey who proposed investment -income curve (TANG Leng-xiao &GUO Xi-bao, 2006) (Figure 2), when the safety investment is zero, there is no security or in a completely natural state, the safety income is zero. The amount of safety investment is greater, the safety degree is higher and the safety income increases, when the safety degree is up to a certain extent, increasing safety investment lead to diminishing of security marginal income. In the Y and Z points, B(safety income) = P(safety investment), it shows that the safety input cost is equal safety income, net income is zero. Investment amount is between 0 and P1, the input costs is more than income, net income is negative. However, the income increases with investment and the marginal income is greater than marginal cost. The investment amount is between P1 and PZ, the income outweighs the cost, net income is positive. However, after the point of P2, the income appears decreasing with investment increasing, so that marginal income is less than marginal cost. When net income is the largest at the point of P2 (NR), which is the best safety investment point.

According to safety investment–safety income curve, the United States, Australia, Canada and other advanced countries' coal mine industries are capital-intensive industries and have high degree of mechanization, the safety investment point is more than P1, which have entered into a virtuous circle track that the safety income is greater than safety investment. China coal mine enterprises safety investment is polarized seriously: one pole is a very small number of advanced coals whose safety investment broke into security restrictions of P1, such as the Shendong mine of the Shenhua Group has invested 800 million yuan to the technological transformation in safety infrastructure and protective devices, it achieves a fully automatic mechanized coal mining . In 2004, the million tons mortality was only 0.01, which is better than the U.S. average. The other extreme is backward coal mines which number are almost impossible to define and have low level of mechanization, the safety investment is below at P1 point and the prevailing security investment is serious shortage. This associates with some factors such as huge safety investment, lagged and concealed safety income, accidental security

incidents which generates luck and lower accident claims cost, this may easily leads business leaders to lack of safety consciousness, they don't understand the relationship between safety investment and income, they appear short-sighted behavior, don't make appropriate coal mine safety investment measures program and don't discover and eliminate coal mine safety risks.

All these are much directly linked with people' unsafe behavior and lack of safety awareness, the establishment of safety performance management system can regulate people's behavior and help to reduce coal mine accidents.

3. CURRENT COAL MINE PROBLEMS ABOUT SAFETY PERFORMANCE MANAGEMENT

3.1 Part of the coal mine enterprises have not established safety performance management system

In the modern human-machine system, man is the dominant factor. Numerous studies and surveys indicate that unsafe behavior is the main cause of the accident. 58% to 86% of accidents connect with human factors in the coal mine work (CUI Guo-zhang, 2004). However, the human behavior is relevant to incentive mechanism. At the same time, as the most important social subject for promoting social and economic development, enterprises have their pursuit of value in the course of operation, business safety performance management system constraints unsafe behavior, which is the most important factor affecting enterprises to adhere safety production objective. Therefore, safety performance management system whose main security objective is incentives and constraints plays a very important position in the enterprise safety production. Safety production has a high degree of relevance with its safety performance management system.

In recent years, most of the coal mine enterprise has recognized that performance management system is importance to safety production, but the actual implementation and operation process are still a lot of errors, performance management system does not integrate into the concept of safety management, so the implementation of the results is poor. Enterprises have not constructed security performance management system really suitable for themselves. Safety performance management system is the important part of business strategic management and security measurements planning, it is core work of human resources management and safety management departments, the lack of performance safety management system leads coal mine workers to lack of safety awareness so that coal mine accidents are inevitable.

3.2 Safety performance index is not scientific

Setting safety performance index is the key prerequisite whether safety performance management can meet the intended purpose or not. The greatest obstacle that many coal mine enterprises encountered in the implementation of safety performance management is how to configure the safety performance assessment index and the corresponding evaluation criteria, the appraisal content failed to highlight the important position of safety production. For example, in the aspects of evaluation criteria and objectives, most companies are reflected morality, ability, diligence, and achievements, the pursuit of assessment is exhaustive in all of these areas. But the key indicators of affecting safety production, such as: million tons mortality, thousands of serious injuries rate, the rectification ratio of potential safety problems, all of these indicators have not received enough attention, so it ultimately affected the enterprises safety performance.

3.3 Safety performance management system has not proposed safety improvements

Performance results should be assessed and feedback, identifying the gap between enterprise expectation safety performance and the actual safety performance, analyze the causes from the organizational level or individual level of and propose measures for improvement. If it is organizational reasons, it is necessary to conduct departmental structure or work process redesign; if it is staff reasons, it is necessary to improve their safety awareness through training or education and regulate safe behavior. Currently, most of China's coal mine enterprises make performance management be equivalent to performance evaluation because of the long-term impact of the closed personnel management system, don't analyze the reasons for the performance assessment results formation and don't propose the corresponding safety performance improvements. After the occurrence of big safety accidents, the state and society held legal liability of those men responsible for the accident from a legal perspective, and performance appraisal system that should play a preventive role of prior has failed to play its due role in the enterprise (FENG Cui-e, 2009). This is related to that enterprise safety performance management system does not make the appropriate safety improvement measures.

Classical economic theory thinks that every society individual is a rational economic one who can act their own rational choices, and the role of the system is that gives these behaviors on a reasonable guide from the norms. Game theory thinks that a system arrangement is to be valid, it must make the interests of the parties to reach Nash equilibrium, or arrangement of such a system will be inefficient. Nash equilibrium is achieved through the choice of the final game to reach equilibrium that relevant stakeholders regard the maximization of their self-interest rules as a condition. The main achievement of benefit-sharing mechanisms is related to that the system reflects in the resource configuration. By building Enterprise safety performance management system, it is a reasonable restriction of production behavior of internal staff, balances the pursuit of enterprise economic efficiency and safety conflicts. By setting the quantified safety performance index, increasing the punishment for unsafe production, forcing internal staff to regulate unsafe behavior, it can achieve the Nash equilibrium among the Government, businesses and staff (WANG Yun-gang, 2007).

4. CONSTRUCTION OF COAL MINE SAFETY PERFORMANCE MANAGEMENT SYSTEM - A CASE STUDY OF PRODUCTION MANAGEMENT DEPARTMENT

Organizational structure of coal mine enterprises includes basically production management department, production scheduling department, syndicated plan department, de measuring management department, coal quality management department, these departments are regarded as coal mine enterprises function department and are received the leadership of manager office. The safety performance of production management department takes a more important influence for coal mine safety and production. Therefore, we will construct safety performance management system taking production management department as an example.

The safety performance management system of production management department is built through four parts such as safety performance plan, safety performance implementation and management, safety performance evaluation and safety performance feedback etc. In the process of determining the department's safety performance plan, at first, we must determine the department's safety performance objectives under the enterprise safety goals to be achieved, secondly, we must set safety performance management system indexes and evaluation criteria of department, and finally, we promote to achieve all safety objectives through establishing good communication mechanism and concerted action between the upper and lower department after the performance appraisal feedback and application.

4.1 Definitude safety performance management objectives of production management department

Safety performance management objectives expand safety production to have primary and secondary, the controlled and efficient management according to strategic planning and safety plans of coal mine enterprises. Regarding 'Security is a primary condition for all the work' and 'all the accidents and injuries can be avoided' as the guide, we consider the coal mine safety target set to 'zero deaths of coal production', according to the principle the objective decomposition and ensurement level by level, safety performance objective of production management department can be set to 'zero serious injury accidents' in order to determine safety performance objectives of the workshop, the team and individual were zero minor injury accidents, no security problems and no illegal behavior under production management department. Figure 3 shows safety performance objective content in the performance management for coal mine 'zero' safety accident. This model will decompose enterprise safety objective from the top level to staff level, by encouraging departments and staff to participate in order to achieve the safety objectives of the production management department.

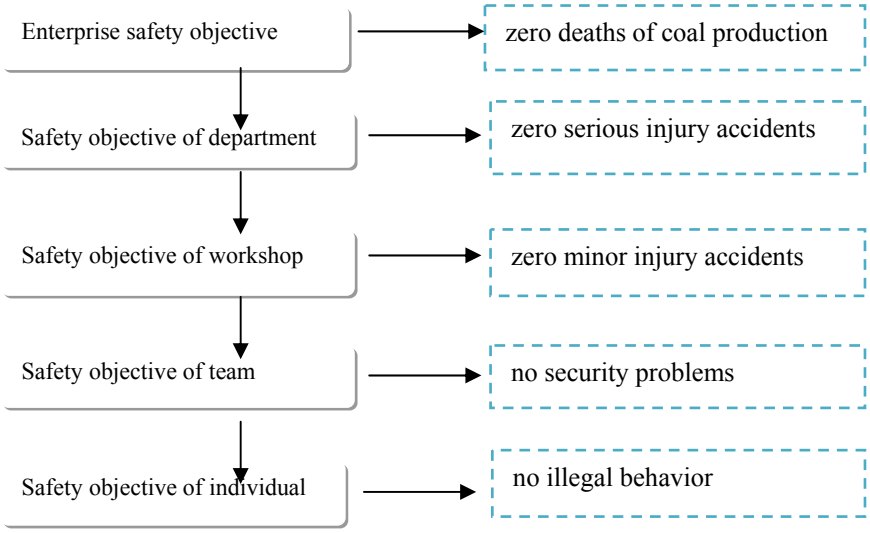

Figure 3: Safety performance management objectives decomposition chart

4.2 Establish safety performance evaluation appraisal system of production management department

Table 2: Performance evaluation system of production management department in coal mine

Safety performance evaluation appraisal index system of production management department				
1 level indicator	2 level indicator	**1 level indicator** weight P_i	2 level indicator weight P_{ij}	2 indicator assessment scores S_{ij}
Security organization setting up A1	Security management organization setting up A11	P_1	P_{11}	S_{11}
	Security management staffing A12		P_{12}	S_{12}

To be continued…

Continued…

Safety performance evaluation appraisal index system of production management department				
Production operations management B1	Implementation of OSHMS standardization B11	P_2	P_{21}	S_{21}
	Rate of employee unsafe behavior B12		P_{22}	S_{22}
	Operating environment quality and climate B13		P_{23}	S_{23}
	The use of toxic substances B14		P_{24}	S_{24}
	The use of personal protective equipment B15		P_{25}	S_{25}
	Coal mine machinery equipment security B16		P_{26}	S_{26}
Hidden risk handling and accident prevention C1	Coal mine major hazard identification and evaluation C11	P_3	P_{31}	S_{31}
	Rectification ratio of mine hidden risk C12		P_{32}	S_{32}
	Major coal mine accident emergency rescue C13		P_{33}	S_{33}
	Draw up and implementation of safety measure plan C14		P_{34}	S_{34}
Completion of safety training D1	Safety training institutions setting up D11	P_4	P_{41}	S_{41}
	The quality of safety training teachers D12		P_{42}	S_{42}
	Safety training program implementation D13		P_{43}	S_{43}
	Completion of safety training D14		P_{44}	S_{44}
implementation of security system E1	Safety culture and system building E11	P_5	P_{51}	S_{51}
	Discipline violation rate during the employee evaluation E12		P_{52}	S_{52}
Accident hazards and losses F1	Million tons mortality F11	P_6	P_{61}	S_{61}
	Serious injury rate per thousand workers F12		P_{62}	S_{62}
	lost workdays F13		P_{63}	S_{63}
	Accident direct economic loss F14		P_{64}	S_{64}
Safety assessment score X	$X = \sum_{i=1}^{6} P_i f_i$ 且 $f_i = \sum_{j=1}^{n} P_{ij} S_{ij}$			

Table 2 shows the content of performance evaluation production management department for coal mine enterprises[4]. By AHP. By constructing the matrix and inviting experts to score, calculate the weight

[4] Standards Australia, Standards NewZealand, Occupational health and safety management systems-general guidelines on principles, systems and supporting techniques,AS/NZS4804, 1997; Australia Health& Safety Organization, Safety management achievement program, Safety Map: The Organization,1997; WANG yun-gang, (2007). "Safety management by objectives in the coal mine safety management", *Mine Safety and Labor Protection.* pp.32-34.

coefficients P_i of each 1 level indicators and the weight coefficients P_{ij} of each 2 level indicators, according to the different weights to determine the key safety performance index (KPI). In addition, according to the real production of the coal industry, determine the corresponding evaluation criteria of each 2 level indicators, and thus we determine each 2 level indicator scores of the actual coal mine enterprises under the specific production circumstances, which form the ultimate safety performance evaluation scores of production management department. In the appraisal process, safety performance appraisal cycle must be clear, such as monthly or quarterly cycle, at the same time, we must know which department should provide the data information in order to ensure the accuracy of evaluation results.

4.3 Safety Performance evaluation and feedback

Safety performance assessment, the enterprises measure quantitative and qualitative safe working behavior of departments through a certain method, in short, enterprise leadership do a systematic evaluation of the department safety work. As an important link of safety performance management system, Safety performance feedback will be timely feedback the safety performance results to be assessed department, make department understand their work, promote the department to improve their work. During safety performance evaluation and safety performance feedback, it is necessary to maintain fair, just and open the basic principles of minimizing the impact of human factors**.**

4.4 The application of safety performance evaluation results

According to departmental safety performance assessment results, identify the safety performance gap between enterprise expectations and the department reality, and analyzes the gap, set diagnosis up the work flow, departmental structure settings from enterprise view; then determine the performance improvement content, draw up performance improvement plans and implement performance improvement (SUN Zhong-hu, 2007). Table 3 shows how to determine the appropriate level by department examination results. Because the assessment achievement is related to life safety of coal mine workers, so the minimum requirement for safety performance examination achieves 70 points, and determine the appropriate safety improvement measures according to level.

Table 3: Safety performance assessment result application of Production management department

Final assessment scores **x**		Improvement
Excellent	90≤X≤100	Department year-end safety award floating 20%, appraising department priority firstly
Good	85≤X < 90	Department year-end safety award floating 10%, appraising department priority firstly
General	80≤X < 85	Department year-end safety award does not go up，Cancel department appraising priority status
Relatively bad	70≤X < 80	Cancel department and its leadership appraising priority status, train critical person in charge for safety, until it reaches the job requirements.
Bad	X < 70	Restructure of the institutions, redesign the post, the responsible persons in charge are dismissed or transformated post.

Assessment level of production management department staff on a monthly or quarterly is linked with their department' assessment level: For example: If the number of the general staff joined in the performance evaluation in production management department is more than 15 persons (including 15), then the distribution ratio of staff safety evaluation grade could be considered as Table 4:

Table 4: Production management department staff safety evaluation ratio distribution

Department employs over 15 persons		Production management department staff safety evaluation ratio distribution（%）				
		Excellent	Good	General	Relatively bad	Bad
safety performance evaluation grade of production management department	excellent	15	25	60	0	0
	Good	10	20	65	5	0
	General	5	15	70	5	5
	Relatively bad	0	15	70	10	5
	Bad	0	0	10	70	20

Table 4 shows that if safety performance assessment grade of production management department is good, then the excellent staff safety evaluation grade can have up to 10% in the department, the good staff safety evaluation grade can have up to 20% in the department, at least 5% of staff safety assessment was rated as bad. The ratio of distribution can be adjusted accordingly combining with the actual production enterprises. In addition, if the number of production management department staff is less than 15, the security assessment ratio can be adjusted through the completion of the key performance indicators, which is to promote coal mine safety production by safety performance assessment.

Be noted that, in all stages of safety performance management should have some mechanism to ensure that all departments with regular or irregular performance of the exchange and communication. All departments should understand enterprise strategy planning and safety plans, the feedback communication of information should be collated and amended in a timely in order to complete the safety performance management objective of ‘zero serious injury accidents ’for the production management department.

5. CONCLUSION

Constructing of safety performance management system can regulate violations of mine employees, encourage their employees to play a crucial role in safety. This paper is limited, safety performance management system is only constructed of the production management department in the coal mining enterprises, safety performance assessment indicators are given and the assessment methods are determined. If conditions allow, safety performance appraisal system of staff can be constructed suitable for coal enterprises. Combining with department safety performance appraisal results to determine the coal mine employees the ultimate safety performance appraisal ratio, we can establish a reasonable safety incentives and provide the occupational career design for the coal mine employees, thus it can protect the health of mine employees while further promote the coal mine healthy safety development.

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