Study on coal mine safety management system based on “Hazard, Latent Danger and Emergency Responses”

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Abstract

Based on problems in China’s coal mine safety management and root cause of the accident, the differences and connections of the hazards and risks were analyzed and identified to find stresses of safety management in coal mines. Then, a coal mine safety management system based on hazard, latent danger, and emergency response was established for the improvement of coal mine safety management.

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1. Introduction

In recent years, as the government and the community pay more attention to mine safety work, the accident number and fatalities decline gradually. However, the accident number is still very high and the status of safety work remains serious. For example, in 2012, there occur 779 coal mine accidents and 1384 fatalities, which are dropping by 35.1% and 629.9%, and FPMT (fatalities per million tons), fell to 0.374. But FPMT is still as ten times as the number in USA. Therefore, it is necessary to strengthen the country's coal mine safety production.

According to statistics, more than 90% of coal mine major accident is due to improper management. The hazard is the root of an accident, and latent danger is the direct cause of an accident. Emergency response is to minimize the possibility of accidents and reduce losses. Therefore, safety management is mainly focusing on management of three

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core elements which are “hazard, latent danger and emergency response”. However, there still exists a misunderstanding or confusion on the concepts between hazard and latent danger, resulting in difficulty to discern objects of safety management and divide target responsibility. Coupled with lack of comprehensive safety management system, the safety management efficiency is very low. Therefore, it is necessary to take steps in exploring the concepts of hazard and latent danger, identifying the differences and connections, and establishing an safety management system based on “hazard, latent danger, emergency response” to improve the safety management level in coal mines.

2. Status of safety management in coal mines

At present, China's coal mine safety management is mostly based on experience, management techniques is relatively backward. Traditional safety management mode is commonly used, which pays attention to safety just after the accident. However, it is difficult for this management model to curb accidents from the source. By analyzing China's coal mine safety management status, we find the following problems: (1) Coal mine safety management techniques are relatively backward. (2) Coal mine safety investment is inadequate. (3) Safety education is not enough. (4) There is confusion and even misconceptions between the concepts of hazard and latent danger. (5) Safety Management System is not easy to be implemented.

3. Analysis of hazard and latent danger

Currently, the definition of hazard in academia has not been uniform. Wu Qiong, Xu Kai considered that hazards are devices, facilities or places existing in the system that may accidentally release energy or hazardous substances[1]; Luo Yun, Xu Deshu refers hazards to the proposed regions, places, spaces, jobs, equipment and locations in a system which contain potential hazardous energy and might be converted to accidents under certain triggers[2]; The definition of hazards in OHSAS18001 are roots or conditions which could lead to injury or illness, property damage, environmental damage, or combination of these states[3]. However, the author of this paper believes that the hazard is the root of accidents, and the hazard should be including dangerous substance, energy and environment and excluding the human factor, since the human factor belongs to latent danger.

According to the definition from “Regulations on Investigation and Management of Accident Latent danger”, “latent danger” is unsafe conditions of objects, unsafe behaviours of people and defects in managements led by violation of safety laws, regulations, rules, standards, procedures, or other factors.

A hazard and a latent danger are not the same, but they are related somehow. The hazard, belonging to a normal condition, is the root of an accident and inherent in the production process and independent of human being’s will. Besides, the fatalness is one of their properties, which only could be identified and controlled; the latent danger, belonging to an abnormal condition, is the direct cause of an accident, and could be completely eliminated after investigation and management. Control loss of hazard will leads to a latent danger[4], that is, a latent danger plus a prevention insufficiency is an accident, as is shown in Fig. 1.

![Fig. 1. Relationships among hazard, latent danger and accident.](image-url)
To sum up, only when hazard and latent danger is in control, can we curb accidents radically. In view of the safety management is mainly target at the accident, therefore, the hazard and latent danger management has become an important aspect of safety management.

4. Establishment of safety management system in coal mines based on “Hazard, Latent Danger and Emergency Responses”

4.1. System design and operation overview

Safety management system based on “hazard, Latent Danger and Emergency Responses” emphasizes the idea of people-oriented and sets accidental prevention as the primary goal. The system regards risk pre-control as the core and focuses on management of hazard and latent danger during the full life cycle (design, construction, production, expansion, etc.), and strive to control hazard and eliminate latent danger, and reduce accident losses to an acceptable level through effective emergency response.

The system mainly consists of 2 subsystems, one is “three core elements” and the other is “six support elements”. The “three core elements system” is the core of the entire system, including hazard management, latent danger management and emergency response management; the “six support elements system” is the foundation of the entire system and provides organization, system and materials for the entire management.

Safety management system based on “Hazard, Latent danger and Emergency Responses” adopts PDCA cycle by the U.S. expert Dai Ming as operation mode, which includes 4 stages-plan, do, check, action. The model applies not only to main system, but also sub-systems. The system runs in a closed loop. The framework of safety management system is shown in Fig. 2.

![Fig. 2. Framework of Safety management system based on “Hazard, Latent Danger and Emergency Responses”](image)

4.2. System main content

4.2.1. Management of hazard

The hazard is factor inherent in all production systems and leading to accidents, which cannot be eliminated and could only be identified and managed.

1) Identification of hazard. Identification of hazard is to identify hazardous objects hiding in production process by scientific and effective way, analyse its characteristics, existing requirements, triggering factors and the severity
of the consequences, and classify different sources and register them[5]. In general, the objects of identification includes major hazard in mine production, major work places, hazardous underground operations, general underground operations, major facilities and equipment. It could be analysed in double ways, global-local way and qualitative-quantitative way. There are three procedures: 1) master the mechanism of different accidents; 2) measure and analyse basic conditions of underground mining; 3) analyse processes and equipment of mine production.

(2) Monitoring of hazard. Monitoring of hazard refers to monitoring on identified explicit and implicit hazard in the system to control their status changes. Usually, there are real-time, regular and irregular ways for dynamic monitoring. We need take into consideration the characteristics and severities of hazard when determining the range and method of monitoring. There are several steps in monitoring of hazard in coal mine system: 1) Identify the thresholds of different monitored objects and procedures according to the actual situation of the mine; 2) Inspect reliability of monitoring equipment; 3) Check and analyse the reliability of collected data, including analysis of abnormal data and analysis of system trend, etc.; 4) Establish the corresponding monitoring system with computers, type in data into the management system timely, pass them to relative departments and judge risk level, and finally set up a series of warning system.

(3) Control of hazard. Control of hazard refers to controlling hazard by engineering and management ways according to the characteristics and monitoring data of hazard and preventing them to cause accidents. The relative techniques are divided into three categories: intrinsic safety technology, accidental prevention technology and loss reduction technology[6]. Since different sources have different characteristics and triggers, we shall select way to control them according to actual situations. In coal mines, prevention scheme shall be made for major disasters. The prevention scheme can be developed as coding, reviewing approving. To ensure the scheme to be effective, we should pay attention to the following three points: 1) Appropriate technical supports. Companies need to focus on their own technical reserves and personnel reserve, such as filing for existing technology and personnel and create advanced technology to support the development of companies. 2) The scheme should be suitable to hazard. Adjust the scheme regularly to meet requirements. 3) Feasibility of scheme. Take into consideration the execution of company and reliability of the scheme.

4.2.2. Management of latent danger

Latent danger, not inherent in the system, appears with the system running. They can be managed by pre-control, investigation, elimination with a closed-loop management system.

(1) Latent danger pre-control. Latent danger pre-control, based on identification, monitoring and control of hazard, is to analyse potential latent danger and eliminate them at the early stage. Analyse the system globally first and locally sequence, and establish latent danger pre-control system corresponding to management of hazardous sources. In general, there are three aspects in pre-control work of coal mines: 1) Technical measures. Identify possible latent danger before the latent danger is forming by operation standards and quality requirements, and pre-control the latent danger; 2) Safety behaviours of personnel. Such as monitoring and control of indicators of personnel and conditions; 3) Set up relative regulations for abnormal situations.

(2) Latent danger investigation. Latent danger investigation is a key aspect of latent danger management, which would affect accidental risks directly. Coal mine enterprises shall set up long-term mechanism to investigate potential latent danger on unsafe behaviour of people, unsafe conditions of objects and environments and defects of management. There are four categories in such investigations: daily investigation, on-duty investigation of investigators, regular safety investigation, and safety investigation by higher authorities. When investigation work is carried out, we need pay attention to the following three points: 1) Set up of safety investigation plan; 2) Management in classification and categories; 3) Establishment of procedural latent danger management system.

(3) Latent danger management. Latent danger management means eliminating latent danger or reducing their hazardous degree. In general, the latent danger management can be divided into: 1) Latent danger rectification. Latent danger classification shall proceed, based on specific condition, according to "three confirms": that is, “Confirm time”, “Confirm measures”, “Confirm responsible person”; 2) Latent danger review and acceptance. That is, review every rectification item and accept the item only if the rectification had real effects. If the items are unqualified, we need punish responsible persons. 3) Information management on latent danger. All latent danger data shall be typed in information system and analysed as zoom, team and major, and control their rectification
4.2.3. Emergency response

Effective emergency response includes emergency measures, emergency capacities and contingency plan.

(1) Emergency measures. The main purpose of this process is to eliminate or control the disaster at the early stage, and prevent disaster from spreading to other nearby areas [7]. In coal mine enterprises, we should set up emergency measures in advance according to the characteristics of workplaces, and organize relevant personnel to exercise regularly.

(2) Emergency capacities. Emergency capacities provide material supports and self-rescue skills to trapped personnel, which mean a lot to emergency rescue. Generally, there are 2 parts included in emergency capacities: 1) Construction of “six sub-systems”, which refers to monitoring and control system, personnel positioning system, emergency hedging system, press-air self-rescue system, water-supply rescue system liaison and communication system; 2) Development of emergency response of personnel. This process can be achieved through training and education.

(3) Contingency plan. Contingency plan is a kind of action plan made for potential accident, which includes comprehensive contingency plan, specific contingency plan and field disposal plan [8]. Coal mining enterprises should make up specific contingency plan and field disposal plan for all types of possible accidents, and identify responsible person during the whole process of an accident. Besides, coal mining enterprises shall regularly organize workers to learn and practice plans, and ensures workers could proceed normally when accidents appear.

4.2.4. System security

According to different functions, the security systems could be divided into safety culture security, organizational security, regulation security, operation security, technical security, financial security. Safety culture security means to construct a comprehensive safety culture environment after which managers and workers would realize and regard safety [9]. Organizational security means to identify an effective organizational framework and specify responsibilities on different persons. Regulation security means to set up a comprehensive system of regulations according to laws and enterprise’s self-conditions. Operation security includes supervision sub-system and self-improvement sub-system. Financial security refers to support of finance on safety management in coal mines.

5. System implementation

Coal mine enterprises shall establish a safety management system as followed.

(1) Identify the orientation, objective and commitment of safety management. In this item, the high-level managers shall organize the whole personnel to discuss the orientation, objective and commitment of safety management according to demands of laws, enterprise size, past and current safety achievements. Besides, the responsible of the enterprise shall make safety commitment and keep the system running.

(2) Establish an organization for safety management, and clarify responsibility of each position. Coal enterprises can set up a leading group of safety management, which consists of a sub-system for system operation and a sub-system for supervision, and clarify responsibility of each position to ensure whole-personnel participation.

(3) Form a series of files. Form a series of files Include files on orientation, objective and commitment of safety management, key position and responsibility, list of major hazard, regulations and laws, procedures and other relative work.

(4) Conduct training and education on the system. In coal mines, we shall adopt different ways to promote safety knowledge, and make personnel realize the importance of the system, and finally create an environment of safety culture. Besides, we shall carry out training work on safety system and teach workers to survive on the ground and underground.

(5) Test run of safety management system. Department of execution shall take the responsibility to tutor other departments on test run of system. In this item, other departments shall do work on safety management, which is
about identification of hazard and control of latent danger, under assistance of department of execution. Besides, department of supervision shall supervise the test run during the whole process.

(6) Review and continuous improvement. In this item, we shall carry out internal and external review on safety achievements and find out the existing problems, and finally make efforts to ensure the continuous improvement of system.

6. Conclusions

(1) By description on relationships among hazard, latent danger and accidents, we know that the key elements in accident prevention are hazard management and latent danger management.

(2) The coal mine safety management system based on “hazard, latent danger and emergency responses” content is clear and definite. The system make the focal points stand out, which is easy to use in coal mines.

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