



Application of Modern Safety Management Science in Coal Mine Safety

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Abstract: Modern safety management science is a safety management system based on scientific methods and systematic theories, with the core goal of preventing accidents, reducing risks, and ensuring personnel safety. It advocates comprehensive safety management across multiple levels, including source control, risk assessment, and emergency response. The application of modern safety management science in coal mine safety is of significant importance. Modern safety management science emphasizes emergency response and disaster management. Coal mine accidents are often sudden and complex, posing higher demands on emergency response and disaster management. Modern safety management science improves emergency response capabilities and disaster management levels among coal mine personnel by establishing a comprehensive emergency management mechanism and training system, thereby effectively addressing emergencies during accidents and minimizing casualties and property damage.

Keywords: Management Science; Coal Mine Safety; "2-4" Model; Safety Human-Machine Interaction

1. Introduction

The value of modern safety management models and methods in corporate management lies in protecting employees and asset safety, improving operational efficiency and productivity, complying with legal and regulatory requirements, and enhancing the company's image and reputation. By effectively implementing safety management measures, enterprises can reduce risks, improve performance, and lay a solid foundation for sustainable development. Especially in the ongoing development of coal mining enterprises, coal mine safety management is crucial for enhancing the company's overall strength and has a profound impact on social harmony and steady progress.

In the new era, as the depth of coal mining continues to increase, more safety issues are emerging for safety managers. The orderly implementation of coal mine safety management can ensure improved operational safety, meet the expanding needs of coal mine development, and safeguard the lives of workers and the security of collective property. The role of modern safety management science in coal mining enterprises involves using targeted measures to address key issues in each link of coal mine safety management, scientifically eliminating safety hazards, and laying a strong foundation for the steady advancement of coal mining enterprises. This contributes indelibly to achieving safer, more efficient, and systematized production.

2. Background

Based on the continuous development of safety management science, it has played a significant role in various production and business enterprises, especially in coal mining enterprises. Modern scientific methods can be integrated into all aspects of coal mine production. Initially, safety management focused primarily on emergency response and accident investigation. With the accumulation of related accidents and management experiences, coal enterprises have gradually shifted their focus of safety management science towards labor



protection, systematized management, and comprehensive risk management. More emphasis is now placed on accident and occupational injury prevention, through improving work environments, providing personal protective equipment, and training employees to safeguard workers' lives and health. Furthermore, safety management systems have been continuously improved by establishing measures such as risk assessment, safety training, management responsibilities, and performance evaluation. Nowadays, safety management not only addresses traditional safety risks but also incorporates other risk factors. Comprehensive risk management emphasizes the entire process of risk identification, assessment, control, and monitoring to minimize potential negative impacts.

The role of modern safety management is particularly important for coal mining enterprises. Due to the numerous risks in the coal mining industry, such as gas explosions, roof collapses, and coal dust explosions, safety management is crucial for protecting the lives of coal miners and the security of assets. Modern safety management methods help coal mining enterprises identify, assess, and control potential safety risks, providing a scientific framework and tools for ensuring safe production.

In practical production applications, the methods encompassed by modern safety management science play an important role in risk management for coal mining enterprises. Su Guorui¹ developed a system for the graded control and hazard inspection of coal mine accidents, assessing risks and control measures to help coal mining enterprises identify and reduce various safety risks. Zhou LJ² proposed strategies by analyzing coal mine safety education and training methods under the new conditions, addressing both internal and external causes of coal accidents. Bai JY³ compared coal mine accident investigation reports from China and the U.S., concluding that China should continue to introduce relevant regulations to standardize accident investigation reports, and suggested that the cause analysis in such reports should adopt a more scientific approach, using logical relationships between causes. He XQ⁴ proposed the principles of business and control decision-making within the technical management system, based on the perspective of business and decision-making authority division.

In specific mining operations, safety management efforts can strengthen interdepartmental communication⁵, ensure coordination between departments, and facilitate high-level and high-quality work through collaborative efforts. This successfully reduces the likelihood of safety accidents, minimizes property damage to mining enterprises, and maximizes the safety and standardization of mining and other operations, thus enhancing the overall competitiveness of mining enterprises⁶. Therefore, in-depth exploration of my safety management is essential and of significant practical importance.

3. Issues in Coal Mine Safety Management

Insufficient safety awareness among workers. Safety awareness refers to the psychological activities related to the conditions and states that protect an individual's physical and mental well-being from adverse factors. In coal mining activities⁷, it is the psychological state of vigilance and caution towards any objective factors that may harm oneself or others. Coal miners often lack an adequate understanding of the importance of safety awareness, making them more likely to overlook potential safety risks, thus increasing the probability of accidents. There is significant individual variation in the psychological, knowledge, and physical states of workers, leading to considerable differences in behavior when facing coal mining tasks. While workers may have a vast amount of safety knowledge stored in memory during coal production, the knowledge they actually activate in practice may be limited. Workers may also experience physical fatigue, which can reduce their safety awareness from both subjective and objective perspectives⁸.

Inadequate safety training. The goal of safety training is to equip workers with comprehensive safety awareness, extensive safety knowledge, and correct safety behaviors. This enables them to identify and address potential safety risks, operate equipment and tools properly, and ensure both personal and coal mine production safety. Additionally, training aims to stimulate workers' initiative and creativity, encouraging them to actively engage in safety management and propose improvements, thereby fostering a safe and healthy work environment. Coal mining companies may face issues with insufficient or untimely safety training, resulting in employees lacking the necessary knowledge and skills for safe operations and emergency response. Some mining companies do not prioritize safety training, resulting in a procedural and superficial training process⁹. This directly leads to low safety awareness among both managers and frontline workers, with unclear understanding of accident prevention and response.



Incomplete safety equipment and protective measures. Coal mines face issues such as aging equipment, lack of maintenance, non-compliance with standards, and insufficient personal protective equipment, all of which pose risks to workers' safety. Underground equipment in coal mines is in direct contact with frontline workers, and ensuring the adequacy of safety equipment and protective measures can directly safeguard workers' lives. For example, the "7/13" major flooding accident at Baiping Township Dongfeng Coal Mine in 2003, which resulted in 15 fatalities, occurred partly due to the inadequacy of underground safety equipment and poorly prepared mine safety measures. Updating and maintaining safety equipment and protective measures, conducting regular inspections and maintenance to ensure their proper functioning, and purchasing standard-compliant personal protective equipment are key strategies for effective safety management and worker protection.

Inadequate monitoring and early warning systems. The inadequate monitoring and early warning systems in coal mines have long been a challenge for mine safety production. This issue is primarily due to the complex underground geological conditions and the lack of adequate technical equipment and research in China to address the complex geological disasters in mines. There is also a lack of comprehensive monitoring and early warning method suitable for all types of coal mines¹⁰. Therefore, it is essential to introduce modern monitoring equipment and technology and establish real-time monitoring and early warning systems to promptly identify and address potential safety risks. The lack of effective monitoring and early warning system in coal mines makes it difficult to detect and respond to potential safety risks in a timely manner. This situation undoubtedly poses a disaster for workers involved. It greatly increases the likelihood of workers being exposed to danger and accidents, leading to potential losses in both life and property in the coal mine.

4. Application of Modern Safety Management Methods

Application of Safety Human-Machine Systems in Coal Mines. Safety human-machine engineering is a scientific approach that integrates human cognition, physiological characteristics, and behavior with the work environment. Its goal is to optimize system design and improve safety, health, and work efficiency. In coal mines, the application of safety human-machine engineering can optimize equipment and tool design, improve human-machine interfaces, enhance emergency response and safety training, as well as personnel location and monitoring, and provide psychological and behavioral analysis of workers. The application of safety human-machine engineering in coal mines can optimize system design, enhance the safety of the work environment and equipment, reduce human errors and accident risks, improve work efficiency and job satisfaction, leading to significant improvements in safety management and production efficiency¹¹.

Application of Fatigue Monitoring Technology. Miners' work patterns are diverse, and their activity range is extensive. As deep mining progresses, the causes of miner fatigue become more complex, making it difficult to directly apply existing technologies to monitor head position during work. In the future application of personnel fatigue monitoring in smart mines, miniature monitoring devices, such as heart rate detectors and pulse sensors, can be embedded into miners' gloves and underground work gear¹². Specialized glasses for eye monitoring can be used, or fatigue detection can be performed through eye movement detection before entering the work area. Due to the complexity of the underground mining environment, which includes dust, gas, electromagnetic interference, and equipment noise, these adverse factors must be carefully considered when developing fatigue monitoring technologies for underground settings. This paper discusses a simpler approach for monitoring miner fatigue at the mine entrance, which can currently help avoid the issues mentioned above¹³.

Application of the Human-Centered Principle in Coal Mine Enterprises. The human-centered principle is a management concept that emphasizes placing people at the core of organizational and work system design, focusing on their needs, abilities, and behaviors to improve work efficiency and employee satisfaction. In coal mine enterprises, the "human-centered principle" is a management philosophy that emphasizes placing people at the center, reflecting a profound understanding of human nature in modern society, and is a key characteristic of the development of management theory today. Its essence is to fully affirm the central role of individuals in management, using research on people's needs, motivations, and behaviors to stimulate their initiative, proactivity, and creativity, thereby improving management effectiveness. The management ideas contained in the "human-centered principle" are mainly reflected in the following: employees are the core of the enterprise; effective management relies on employee participation; respecting people is the core of modern management; management exists to serve people. The "human-centered principle" requires placing human factors at the



forefront of management activities. Human factors are fundamental to successful management because all management systems and methods are established by people, and all management activities are carried out by people. Maximizing the potential of individuals is key to improving management efficiency. The safety culture of coal mine enterprises is a multi-layered and complex system, composed of safety material culture, safety institutional culture, safety spiritual culture, safety values, and normative culture.

5. Conclusion

- (1) In the new era, there are numerous safety hazards in mining operations, and mining enterprises need to use scientific methods to eliminate these risks. Since operational safety is easily affected by various factors, mining enterprises should carry out safety management work to reduce the impact of these factors, improving the safety and standardization of operations at all stages.
- (2) The management of mining enterprises should take a comprehensive approach, prioritize mining safety management, and use detailed work to reduce various safety accidents, thus enhancing the overall competitiveness of the mining industry and contributing significantly to the steady development of the national economy. Modern safety management methods also meet the demand for innovation, new methods, and technologies in coal mining enterprises.
- (3) During the mining operation process, safety management is a key factor that influences the successful implementation of the entire project. Through the concept of safety engineering, it ensures the comprehensive and smooth implementation of safety management in mining operations, providing good support for the development of mineral resources.

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