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Safety Risk Pre-Control Management in Coal Chemical Enterprises

Hai-Ping Qu*

Guoneng Yulin Chemical Co., Ltd., Yulin, Shaanxi 719000, China

***Correspondence to:** Hai-Ping Qu, Guoneng Yulin Chemical Co., Ltd., Yulin, Shaanxi 719000, China, E-mail: 20015735@chnenergy.com.cn

Abstract: Coal chemical enterprises are characterized by complex production processes and diverse safety risks with severe potential consequences. Therefore, it is crucial to establish and effectively implement a scientific safety risk pre-control management system. This paper first elaborates on the main types of safety risks in coal chemical enterprises, including fire and explosion, poisoning and asphyxiation, chemical burns, and fall-from-height risks, and analyzes the characteristics and hazards of each type. It then explores the construction of a safety risk pre-control management system, covering the management framework, institutional arrangements, and risk assessment methods. Finally, implementation strategies are proposed. In terms of personnel training, emphasis is placed on strengthening safety awareness, skills training, and safety culture development; equipment maintenance focuses on regular inspection, maintenance, and upgrading; emergency management highlights contingency plan formulation, drills, and resource management; and risk monitoring and early warning promote system construction, the establishment of warning indicators, and the improvement of response mechanisms, so as to ensure safe production in enterprises.

Keywords: Coal chemical enterprises; safety risk; pre-control management

Introduction

As a high-risk industry, coal chemical enterprises involve large quantities of flammable, explosive, toxic, hazardous, and highly corrosive substances in their production processes. In addition, their production installations are large in scale and technologically complex, making safety risk prevention and control particularly critical. Once a safety accident occurs, it may not only result in serious casualties and property losses, but also trigger chain reactions, affecting the stability and development of enterprises and even society as a whole. Therefore, establishing a scientific and effective safety risk pre-control management system and implementing comprehensive and meticulous safety management strategies are of vital importance for coal chemical enterprises. Starting from the main types of safety risks in coal chemical enterprises, this paper systematically expounds the construction of a safety risk pre-control management system and its implementation strategies, with the aim of providing useful references for safe production in coal chemical enterprises.

1. Main Types of Safety Risks in Coal Chemical Enterprises

1.1 Fire and Explosion Risks

In coal chemical production, materials undergo continuous dynamic changes from raw material input to product output. During storage, these substances must be contained in specific vessels and maintained under controlled environmental conditions. If container quality is inadequate or environmental parameters are not properly controlled, the level of risk will increase. During transportation—whether through pipelines or vehicle transport—collisions, leaks, or other incidents may also trigger hazardous situations. In the utilization stage, improper operation can likewise lead to safety hazards. When flammable and explosive substances are exposed to ignition sources such as open flames, static electricity, or lightning strikes, fire and explosion accidents are highly likely to occur. Fire and explosion accidents exhibit several severe characteristics. They are highly sudden, often breaking out without warning; extremely destructive, capable of causing catastrophic damage to surrounding personnel, equipment, and buildings; and wide-ranging in impact, affecting not only the accident site but also adjacent areas. Once such accidents occur, they frequently result in serious casualties and substantial property losses. More critically, they may trigger chain reactions that paralyze the entire production system, causing enormous economic losses to enterprises and disrupting normal production and operation. At the same time, these accidents may exert negative social impacts, such as environmental damage in surrounding areas and threats to social stability.

1.2 Poisoning and Asphyxiation Risks

Coal chemical production processes generate toxic and hazardous gases such as carbon monoxide, hydrogen sulfide, and carbon dioxide. When these gases leak into the working environment, or when workers enter confined spaces without adequate protective measures, poisoning and asphyxiation accidents may occur. Such accidents are characterized by strong concealment and gradual progression. Most toxic and hazardous gases are colorless and odorless, making them difficult for workers to detect through sensory perception during operations. Under normal operating conditions, toxic gases may be released slowly and gradually accumulate in the working environment, leading to continuously increasing concentrations. During prolonged operations, workers may unknowingly inhale these gases, resulting in progressive physical harm. Because this process is relatively concealed, early symptoms may not be obvious, and workers often fail to realize that they are already in a dangerous situation. As gas inhalation continues, discomfort gradually intensifies, and by the time workers become aware of the danger, poisoning may already be severe or even life-threatening. Therefore, in coal chemical production, great importance must be attached to the prevention and control of toxic and hazardous gases. Continuous monitoring of the working environment should be strengthened to promptly identify changes in gas concentrations. Qualified personal protective equipment must be provided to ensure effective protection. In addition, safety training should be enhanced to improve workers' awareness of toxic and hazardous gases and their emergency response capabilities, thereby ensuring operations are conducted in a safe environment.

1.3 Chemical Burn Risks

In coal chemical production processes, strongly corrosive chemical substances such as acids, alkalis, and salts are widely used. If workers are negligent during operations and allow their skin, eyes, or other body parts to come into contact with these substances, chemical burns may occur. Chemical burns are highly hazardous and can cause direct damage to local tissues once they occur. Skin contact may result in redness, swelling, blistering, and ulceration, while eye exposure may lead to visual impairment or even blindness. The pain at the burn site is intense and persistent, severely affecting patients' quality of life. Moreover, the healing process is slow, requiring long-term medical treatment and nursing care [1]. During treatment, patients not only endure significant physical suffering but also face considerable financial pressure. Some chemical burns may result in permanent disabilities, such as limb dysfunction or facial disfigurement, imposing a heavy burden on patients and their families. Chemical burn accidents affect not only individual employees but may also disrupt enterprise production order, increase operating costs, and impose additional social burdens. Therefore, chemical burn risks must be given high priority in coal chemical production. Safety

management should be strengthened by formulating strict operating procedures and safety regulations; protective measures should be improved by providing appropriate personal protective equipment; and employee safety training should be enhanced to improve safety awareness and operational skills.

1.4 Fall-from-Height Risks

Production installations in the coal chemical industry are generally large and tall, and employees often need to perform work at height in their daily tasks, such as equipment installation and maintenance. Due to the special working environment, inadequate implementation of safety protection measures can easily lead to fall-from-height accidents. The consequences of such accidents are severe. From the perspective of physical injury, violent collisions between the human body and the ground or other objects during a fall greatly increase the risk of fractures. Multiple fractures not only cause intense pain but also impair normal bodily functions, prolonging treatment and rehabilitation periods. Craniocerebral injury is another common and extremely harmful type of injury, which may result in coma or concussion and, in severe cases, lead to irreversible consequences such as intellectual impairment or limb paralysis. In addition, fall-from-height accidents often directly result in fatalities. Loss of life not only brings devastating emotional and financial impacts to the victims' families but also produces multiple negative effects on enterprises. In terms of production, such accidents may cause production shutdowns and disrupt normal operations; in terms of equipment, they may lead to equipment damage and increased maintenance costs; in legal terms, enterprises may bear corresponding legal liabilities and face disputes and penalties; and in terms of reputation, accidents can damage corporate image, reduce market trust, and adversely affect long-term enterprise development.

2. Construction of a Safety Risk Pre-control Management System in Coal Chemical Enterprises

2.1 Management Framework

The construction of a safety risk pre-control management system in coal chemical enterprises requires the establishment of a comprehensive management framework, including goal setting, organizational structure, and process design. In terms of goal setting, clear objectives for safety risk pre-control management should be defined, such as reducing the probability of safety accidents, minimizing casualties and property losses, and protecting the environment. Overall objectives should be decomposed into specific and measurable sub-goals to provide a clear direction for safety management activities. With regard to organizational structure, a sound safety risk pre-control management organization should be established, with clear definitions of the responsibilities and authorities of each department and position in safety management. A dedicated safety management department should be set up to coordinate and oversee enterprise-wide safety management, regularly organize safety inspections and risk assessments, and ensure the effective implementation of various safety measures. In terms of process design, a scientific and rational safety risk pre-control management process should be formulated, covering risk identification, risk assessment, risk control, risk monitoring, and early warning [2]. Risk identification aims to identify potential risk factors by comprehensively screening various hidden hazards in the production process, providing a basis for subsequent management. Risk assessment involves quantitative analysis of identified risks to determine risk levels, thereby enabling the formulation of targeted control measures. Risk control refers to reducing risks through engineering controls and management measures based on assessment results. Risk monitoring and early warning focus on continuous tracking of risk conditions, using advanced monitoring technologies and information systems to detect abnormalities in a timely manner and issue warnings. These links are interconnected and coordinated, forming a complete management closed loop that ensures the orderly implementation of safety risk pre-control management, effectively prevents and responds to various safety risks, and guarantees safe and stable enterprise production and operation.

2.2 Institutional Development

In terms of safety management institutional development, it is necessary to establish a comprehensive and well-structured system covering the safety production responsibility system, safety operating procedures, and safety inspection systems. These systems clarify

employees' rights and responsibilities in safety production, standardize operational behaviors, and provide clear guidelines and normative bases for enterprise safety production activities. Regarding the development of the risk assessment system, a scientific and rational framework should be established, clearly specifying the methods, procedures, and standards for risk assessment. Comprehensive risk assessments should be conducted at regular intervals, focusing on production processes, equipment and facilities, and operating environments, so as to accurately identify potential safety risks and provide a solid basis for subsequent risk prevention and control. At the level of emergency management, sound systems should be formulated, covering the preparation, drills, and revision of emergency response plans. Meanwhile, professional emergency rescue teams should be established, and sufficient emergency rescue equipment and materials should be properly allocated. By strengthening emergency management, enterprises can enhance their capability to respond to sudden incidents and ensure that rescue actions are carried out rapidly and effectively in emergencies, thereby reducing accident losses. This approach not only safeguards the lives of enterprise personnel and avoids casualties, but also protects enterprise property, reduces equipment damage and material losses, and maintains normal production and operation order. Furthermore, it helps prevent production interruptions and supply chain disruptions, ensures market supply and corporate credibility, and enables enterprises to develop resilience and the capacity to cope with various safety challenges, thus achieving the organic unity of safe production and stable development.

2.3 Risk Assessment Methods

(1) Qualitative assessment methods mainly include the safety checklist method and the preliminary hazard analysis (PHA) method, which are applied to enterprise production processes and equipment and facilities. These methods focus on identifying potential hazardous and harmful factors and determining their risk levels based on analytical results. The outcomes serve as a key basis for risk control, helping enterprises clarify the direction and priorities of risk management. Through qualitative assessment, enterprises can clearly identify high-risk links and concentrate management efforts on critical areas requiring strict control.

(2) Quantitative assessment methods involve techniques such as fault tree analysis (FTA) and event tree analysis (ETA) to quantify safety risks in enterprises. By accurately calculating the probability of accident occurrence and the severity of potential consequences, risks are defined in numerical terms. Such quantitative results provide solid support for formulating scientific and reasonable risk control measures. Enterprises can allocate resources rationally based on risk values and adopt targeted measures to reduce risks, thereby maximizing the efficiency of resource utilization [3].

(3) Comprehensive assessment methods combine qualitative and quantitative approaches to fully consider the influence of various factors on enterprise safety risks. This method first uses qualitative assessment to preliminarily identify and classify risk factors, clarifying the general scope and categories of risks. Subsequently, quantitative assessment is applied to precisely quantify risks and obtain specific risk values. Through integrated analysis, the limitations of a single assessment method are overcome, and the accuracy and reliability of risk assessment are improved. This approach provides enterprises with more comprehensive and accurate assessment results, enabling them to better understand their safety risk profile and formulate more effective risk management strategies, thereby preventing various safety risks and ensuring safe and stable production operations.

3. Implementation Strategies for Safety Risk Pre-control Management in Coal Chemical Enterprises

3.1 Personnel Training

First, safety awareness training should focus on strengthening employees' understanding of and attention to safety risks. Regular safety knowledge lectures should be organized to enable employees to systematically learn safety-related knowledge and clearly recognize various safety risks and their potential consequences. Safety case analyses should be conducted to thoroughly examine the causes, processes, and lessons of past accidents, encouraging employees to gain experience from real cases, enhance self-protection awareness, and improve sensitivity to potential safety

hazards. Second, safety skills training should be carried out in accordance with job requirements. Based on the characteristics of different positions, targeted training on safety operating procedures should be provided to ensure that employees are familiar with and strictly comply with operational standards, thereby preventing safety accidents caused by improper operations. In addition, emergency response and rescue skills training should be strengthened so that employees can master appropriate methods and techniques for handling sudden safety incidents, enabling rapid and effective action during emergencies and minimizing accident losses. Third, safety culture training should be emphasized to foster a positive safety atmosphere. By organizing safety culture activities such as safety-themed speeches and safety knowledge competitions, employees' enthusiasm for participating in safety management can be stimulated. Safety role models should be established to play a demonstrative role, guiding employees to develop correct safety values. By integrating safety awareness into employees' thinking, safety-conscious behavior can become a voluntary practice, thereby strengthening the enterprise's safety defense at the ideological level. Through comprehensive and targeted training, employees' safety competence can be improved, overall risk prevention and control capability can be enhanced, and a solid foundation can be laid for safe production and stable operation in coal chemical enterprises.

3.2 Equipment Maintenance

Equipment maintenance is a critical component of safety risk pre-control management in coal chemical enterprises, with regular inspection, maintenance, and upgrading serving as key measures. In terms of regular inspection, a sound system should be established to conduct comprehensive inspections of production equipment according to prescribed schedules. Such inspections enable the timely identification of hidden hazards and equipment faults. Once problems are detected, corrective actions should be implemented without delay to ensure safe equipment operation and prevent minor issues from developing into major accidents that could affect production schedules and product quality. With regard to maintenance and servicing, scientific and reasonable plans should be formulated and strictly implemented [4]. On the one hand, vulnerable components should be replaced regularly to prevent equipment failures caused by component damage that may disrupt normal production. On the other hand, internal structures of equipment should be cleaned periodically to remove dust, impurities, and other contaminants, thereby maintaining internal cleanliness, ensuring stable performance, extending service life, and reducing maintenance costs. In terms of upgrading and renovation, comprehensive judgments should be made based on equipment service life and technical condition. When equipment reaches a certain age or its technical performance becomes outdated and unable to meet production requirements, advanced technologies and equipment should be adopted in a timely manner to upgrade or replace existing systems. Through upgrading and renovation, equipment safety and reliability can be significantly improved, the probability of failures can be reduced, and equipment can better adapt to production demands. This not only enhances production efficiency and product quality, but also creates greater economic benefits, strengthens market competitiveness, and promotes the sustainable and stable development of coal chemical enterprises.

3.3 Emergency Management

In the formulation of emergency response plans, close alignment with the actual conditions of the enterprise is essential to develop scientific, reasonable, and operational plans. Emergency organizational structures should be clearly defined, with detailed allocation of responsibilities among members. For each stage—including incident identification, reporting, activation of emergency mechanisms, and rescue implementation—specific emergency response procedures should be clearly specified. At the same time, corresponding emergency rescue measures should be determined for different types of sudden incidents to ensure rapid and effective responses under emergency conditions. Emergency drills should be carried out on a regular basis. By simulating realistic scenarios, the feasibility and effectiveness of emergency plans can be tested, enabling employees to become familiar with emergency response procedures and rescue measures through practice. This process enhances emergency handling capabilities and improves coordination among departments, ensuring that employees can

respond calmly and orderly when emergencies occur. With respect to emergency resource management, a dedicated system should be established for the unified management of emergency rescue equipment and materials, with regular inspection and maintenance to ensure good performance and readiness for use. Emergency resource reserves should be set up according to the types and scales of potential incidents the enterprise may face, including protective equipment, rescue tools, and medical supplies. The quantity and categories of reserves should be reasonably planned to meet actual emergency rescue needs, thereby providing solid material support and enhancing the enterprise's capacity to respond to sudden safety incidents.

3.4 Risk Monitoring and Early Warning

Promoting the construction of monitoring systems is the foundation of effective risk monitoring and early warning. A real-time monitoring system covering key areas such as production processes, equipment and facilities, and operating environments should be established. By utilizing sensor technologies and information systems, safety risk information can be collected rapidly and accurately to provide data support for early warning. Such systems should also possess integrated data analysis capabilities to identify various risk signals in a timely manner and transmit them to the warning module. The setting of early warning indicators should be based on enterprise-specific conditions, with scientifically reasonable risk threshold standards established. These indicators serve as the core basis for determining risk levels and should cover key dimensions such as equipment operating parameters, environmental monitoring data, and operational behavior standards. When real-time monitoring data exceed defined thresholds, the system should automatically trigger warning signals, clearly indicating the type, level, and potential impact scope of the risk, thereby guiding subsequent response actions [5]. Improving the early warning response mechanism is critical. Standardized response procedures should be established, with clear identification of responsible parties at each stage, including warning reception, risk assessment, measure formulation, implementation, and feedback. This enables full-process closed-loop management. Upon receiving a warning, relevant personnel should immediately initiate response procedures and adopt targeted measures—such as equipment shutdown and inspection, isolation of operating areas, or personnel evacuation—according to the risk level, ensuring that risks remain under control. Through these measures, enterprises can form a full-chain prevention and control system covering risk identification, assessment, and disposal, enhance risk perception capability, shorten response time, reduce the probability of accidents, and ensure safe and stable production and operation.

Conclusion

In summary, coal chemical enterprises face diverse types of safety risks. Hazards such as fire and explosion, poisoning and asphyxiation, chemical burns, and falls from height continuously threaten production operations and employee safety. Therefore, establishing a scientific and comprehensive safety risk pre-control management system is of vital importance, in which the management framework, institutional development, and risk assessment methods are all indispensable components. During implementation, personnel training improves employees' safety competence, equipment maintenance ensures stable and reliable production operations, emergency management guarantees effective responses to unexpected incidents, and risk monitoring and early warning enable early identification and timely control of risks. Only by fully implementing and coordinately advancing these strategies can safety risks be effectively reduced, a solid safety defense be built for enterprises, sustainable and healthy development be ensured, and employees' lives and property be safeguarded. Ultimately, this approach contributes to achieving a win–win outcome between economic benefits and social benefits.

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