

## Research on Safety Management in Mine Mining Technology Based on Standardized Grade Evaluation Method

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**Abstract:** In recent years, the scale of mining operations has been continuously expanded. In the mining process, safety management issues have gradually gained importance. Although it has accumulated rich mining experience, due to the harsh mining environment, the mining and mining technology is weak, and the mining technical parameters cannot be adjusted according to the actual situation. Increased the unsafe factors of mining operations, and easily lead to safety accidents. Therefore, it analyzes the main problems in mine safety management, and then uses the standardized grade evaluation method to study the safety management level of mining enterprises in mining technology, assessing the status of its safety management level and finding out its safety management. The existing advantages and weak links help mine enterprises to clarify the direction they need to improve in order to achieve safety objectives, and improve the safety management level of mines.

### 1. Introduction

As the basic industry of our country's economic development, mining is an indispensable part of ensuring the normal operation of society. In recent years, with the increasing attention to mine safety in China, the incidence of mine accidents has been significantly reduced [1]. Because the safety management of mines in China is relatively backward, major accidents occur frequently, which poses a serious threat to people's lives and property. Therefore, to strengthen the safety management of mines and reduce the occurrence of accidents has become an urgent problem to be solved. In order to reduce the occurrence of mine safety accidents, the safety management in mining technology is evaluated by standardized grade evaluation method, which can guide mining enterprises to do a good job of safety management in mining technology according to the standard and improve the level of mine safety management[3].

In order to ensure that safety management is most effectively consistent with the actual production of mining technology, it is necessary to monitor and evaluate the operational status of safety management [4]. At present, the research is mainly on the establishment, operation and maturity of security management, and the research on security management level is relatively rare. Because the factors involved in the mine safety management system are intertwined and complicated, if only certain factors are considered, the actual situation of mine safety management cannot be reflected. With the standardized grade evaluation method, the mining enterprise can identify the weak links in the process of implementing the safety management system, and form an improvement strategy for its process by solving the key problems in the operation of the safety management system [7].

The standardized grading method is to use some observation indicators and categories of known objects, establish one or more discriminant functions according to the discriminant criteria, discriminate the observation samples, obtain discriminant indicators, identify unknown samples, and determine unknown objects [2]. The standardized grade evaluation method has low requirements for sample data and can fully consider the evaluation factors. Therefore, in order to simplify the process of mine safety management level evaluation and accurately reflect the true level of mine safety management, the standardized level evaluation method establishes evaluation. The index establishes a mine safety management grade evaluation model based on the standardized grade evaluation method and is applied to the actual mine safety management level evaluation [5].

## 2. Main problems in safety management of mining technology

The main problems of safety management in mining technology are as follows:

(1) Mining enterprises do not pay enough attention to mining safety. In the process of mining, the personal safety of workers is the most important issue. Our country has also formulated many regulations in this regard. But in practical projects, these regulations have not been effectively implemented. Some enterprises even fail to set up safety measures strictly in accordance with the requirements of the state regulations in order to achieve greater economic benefits. As a result, a series of safety accidents have occurred, resulting in. Personal safety of staff is not guaranteed.

(2) The implementation of security responsibility is not effective. The frequent occurrence of safety problems in mining engineering is partly due to the enterprise's own problems, and partly due to the supervision of the relevant personnel. In actual work, because they did not stop those actions that do not meet the requirements of safety measures, leading to the occurrence of safety accidents.

(3) Lack of advanced professional equipment and technology. Although China's economy has been greatly developed, it still lags behind some developed countries in the West. Therefore, there is a certain gap between China and other developed countries in technology. Our country is not only relatively backward in facilities and lack of advanced technology, but also has some problems in technology.

(4) The level of employees is low. In gold mining construction, because most of the staff members have not received nine-year compulsory education, their cultural quality level is low. For modern machinery, the level of staff obviously can not meet the construction requirements, and some staff members do not even understand the most basic technical safety requirements of gold mining.

(5) Safety management lacks publicity and education. To make the staff pay attention to the hidden safety hazards of mining operations, separate institutions should be set up to train the staff and publicize among the staff. However, many mining enterprises have a series of chain reactions due to the unsatisfactory professional level of safety management personnel, which makes most of the staff members lack safety awareness, thus resulting in safety accidents.

(6) Lack of systematic safety production order and production norms. Mining enterprises should have a systematic safety production order and production norms in construction. Only the planned operation can better manage production work. Especially before the development of the project, all potential safety hazards should be thoroughly investigated, so as to be prepared and safe.

(7) The cost of safety management investment is insufficient. Only by giving enough safety management input to the safety management work of mine construction projects can the safety management work be carried out smoothly. But in some domestic enterprises, they do not attach importance to safety management investment, think that it can not bring economic benefits for enterprises, and also can not obtain short-term safety benefits, so in practice, some enterprises will ignore the investment in safety management, some construction enterprises because of the development is not smooth, the economic burden is relatively serious, there is not enough funds for security.

(8) The responsibility system for production safety is not perfect. Many mines in our country lack corresponding safety responsibility system management in the mining process, which leads to the failure to find the responsible person when various accidents occur, which increases the probability of mining accidents. Due to the imperfect safety responsibility system, the work of the supervisors in the mining production process has gone through the motions, and they do not care about the potential safety hazards.

(9) The security system is mere formality. In order to ensure the safety of mining, the state has promulgated many laws successively. Laws and regulations, such as the Mine Mining Law, the Safety Production Law and the Safety Regulations for Metal and Non-metallic Mines, have also promulgated and implemented relevant industry standards, which have made clear provisions on the safety behavior of mining technology. However, in the actual production process of mines, these rules and regulations have not been strictly implemented in all links of mining, resulting in frequent safety accidents.

Therefore, in the safety management of mining technology, safety management can be classified into three categories and evaluated by standardized grade evaluation method, namely hazard assessment, safety management and emergency response as the main basis for evaluating the quality of safety management.

### 3. Standardized Grade Evaluation Model for Safety Management of Mining Technology

#### 3.1. Index system of mine safety management evaluation

In the mine safety management, the three categories of indicators such as hazard assessment, safety management and emergency response are usually used as the main basis for evaluating the quality of their management. Set the set of indicators that affect the safety management of mines as  $U$ ,  $U_i = (U_1, U_2, \dots, U_n)$ , Each category includes a number of individual indicators, and the set of individual indicators is  $U_i$ ,  $U_i = (U_{i1}, U_{i2}, \dots, U_{in})$ , Here, the evaluation indicators are divided into two levels, namely, the indicators and their subordinate indicators, as shown in Figure 1:

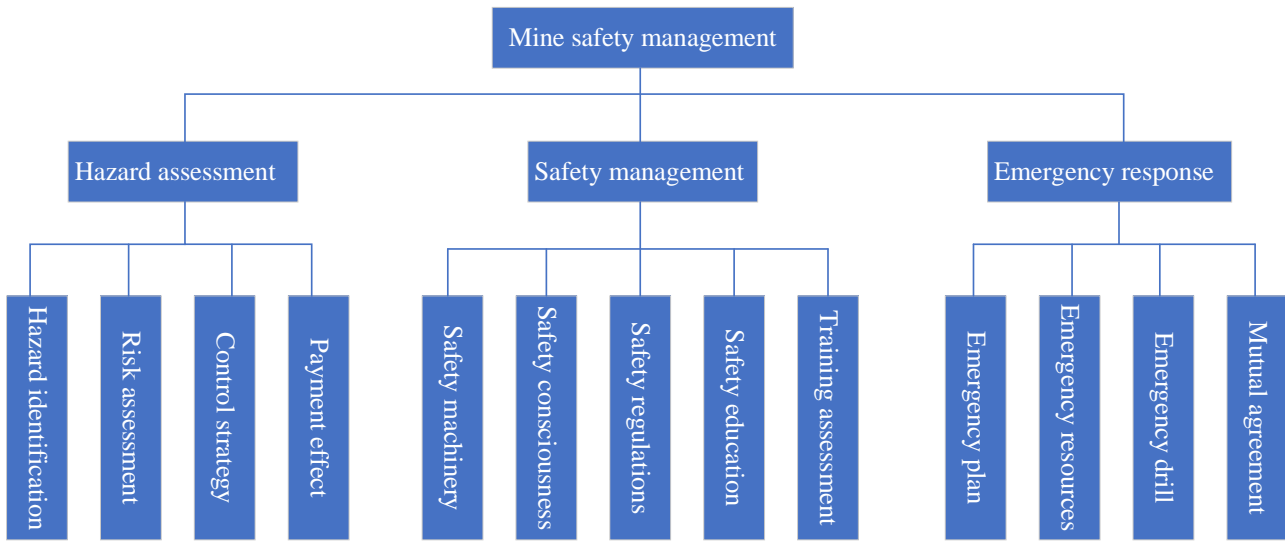


Fig.1. Index system for mine safety management

#### 3.2. Safety management evaluation level set

According to the degree of mine safety management, the evaluation of safety management is divided into five levels: namely, level I, excellent management of safety management; level II, good management of safety management; level III, general management of safety management; level IV, safety Manage qualified enterprises; V-class, safety management is not up to standard enterprises. Thus forming a safety management evaluation level set  $V$ ,  $V = (I, II, III, IV, V)$ . This level set is used to determine the level of mine safety management evaluation.

#### 3.3. Primary evaluation

The first-level evaluation is to evaluate all the individual indicators in each category. Its membership matrix is as follows:

$$R_i = \begin{matrix} U_{i1} \\ U_{i2} \\ \vdots \\ U_{i(n-1)} \\ U_{in} \end{matrix} = \begin{matrix} u_{i11} & u_{i12} & \dots & u_{i15} \\ u_{i21} & u_{i22} & \dots & u_{i25} \\ \vdots & \vdots & \ddots & \vdots \\ u_{i(n-1)1} & u_{i(n-1)2} & \dots & u_{i(n-1)5} \\ u_{in1} & u_{in2} & \dots & u_{in5} \end{matrix} \quad (i = 1, 2, 3) \quad (1)$$

Where  $U_{ijk} (j = 1, 2, 3, \dots, n; k = 1, 2, 3, 4, 5)$  is the membership of the  $k$  element in the level set  $V$  is evaluated for the security management for the single indicator  $U_{ij}$ .

If  $A_{ij}$  is the weight of  $U_{ij}$ , then the weight set of single index set  $U_i$  is:

$A_i = (a_{i1}, a_{i2}, \dots, a_{in}), (i = 1, 2, 3)$ , Then the first-level evaluation model is:

$$B_i = A_i \cdot R_i = (b_{i1}, b_{i2}, \dots, b_{i5}) \quad (2)$$

That is  $b_{ik} = \sum a_{ij} \cdot u_{ijk}, (k = 1, 2, \dots, 5)$ , where  $b_{ik}$  is the first-level evaluation result, the meaning is that after the mine safety management is evaluated according to the class index set, the class index is the membership degree of the  $k$  element in the safety management evaluation level set  $V$ .

### 3.4. Second evaluation

The second-level evaluation is to evaluate the indicators, and the evaluation matrix is:

$$R = \begin{pmatrix} B_1 \\ B_2 \\ B_3 \end{pmatrix} \quad (3)$$

Let  $a_i$  be the weight of  $U_i$ , then the weight set  $A$  of the class indicator set  $U$  is:  $A = (a_1, a_2, a_3)$ , Then the second evaluation is:

$$B = A \cdot R = (b_1, b_2, b_3, b_4, b_5) \quad (4)$$

That is  $b_k = \sum a_j \cdot u_{jk}, (k = 1, 2, \dots, 5)$ ,  $b_k$  is the second-level evaluation result, which means that the mine safety management evaluates the degree of mine safety management to the  $k$  element of the safety management evaluation level set  $V$  after all individual indicators are evaluated.

## 4. Application example

Table 1 shows the inspection results of the safety management of a mining enterprise. The inspection items are divided into 3 categories and a total of 13 individual indicators. The above mathematical models are used for evaluation.

Table. 1. Mine safety management inspection results

Classification	Single indicator	Factor grade				
		Excellent	Good	Medium	Qualified	Dissatisfaction
Hazard assessment $U_1$	Hazard identification $U_{11}$	0.3	0.5	0.1	0.1	0
	Risk assessment $U_{12}$	0.4	0.3	0	0.2	0.1
	Control strategy $U_{13}$	0.3	0.4	0.3	0	0
	Payment effect $U_{14}$	0.5	0.4	0.1	0.1	0
Safety management $U_2$	Safety machinery $U_{21}$	0.3	0.4	0.2	0.1	0
	Safety consciousness $U_{22}$	0.6	0.3	0	0	0.1
	Safety regulations $U_{23}$	0.3	0.5	0.1	0.1	0
	Safety education $U_{24}$	0.4	0.3	0.2	0	0.1
	Training assessment $U_{25}$	0.2	0.4	0.1	0.3	0
Emergency response $U_3$	Emergency plan $U_{31}$	0.4	0.3	0.2	0	0.1
	Emergency resources $U_{32}$	0.3	0.5	0.1	0.1	0
	Emergency drill $U_{33}$	0.2	0.1	0.4	0.3	0
	Mutual agreement $U_{34}$	0.3	0.4	0	0.1	0.2

The first-level evaluation is to evaluate individual indicators. Formula (4) shows that:

$$B_1 = A_1 \cdot R_1 = (0.3, 0.2, 0.3, 0.3) \cdot \begin{vmatrix} 0.3 & 0.5 & 0.1 & 0.1 & 0 \\ 0.4 & 0.3 & 0 & 0.2 & 0.1 \\ 0.3 & 0.4 & 0.3 & 0 & 0 \\ 0.5 & 0.3 & 0.1 & 0.1 & 0 \end{vmatrix} = (0.41, 0.42, 0.14, 0.10, 0.02)$$

$$B_2 = A_2 \cdot R_2 = (0.1, 0.2, 0.2, 0.3, 0.2) \cdot \begin{vmatrix} 0.3 & 0.4 & 0.2 & 0.1 & 0 \\ 0.6 & 0.3 & 0 & 0 & 0.1 \\ 0.3 & 0.5 & 0.1 & 0.1 & 0 \\ 0.4 & 0.3 & 0.2 & 0 & 0.1 \\ 0.2 & 0.4 & 0.1 & 0.3 & 0 \end{vmatrix} = (0.37, 0.37, 0.12, 0.09, 0.05)$$

$$B_3 = A_3 \cdot R_3 = (0.3, 0.4, 0.2, 0.1) \cdot \begin{vmatrix} 0.4 & 0.3 & 0.2 & 0 & 0.1 \\ 0.3 & 0.5 & 0.1 & 0.1 & 0 \\ 0.2 & 0.1 & 0.4 & 0.3 & 0 \\ 0.3 & 0.4 & 0 & 0.1 & 0.2 \end{vmatrix} = (0.31, 0.35, 0.18, 0.11, 0.05)$$

Formula (3) shows that the secondary evaluation matrix R is:

$$R = \begin{vmatrix} B_1 \\ B_2 \\ B_3 \end{vmatrix} = \begin{vmatrix} 0.41 & 0.42 & 0.14 & 0.10 & 0.02 \\ 0.37 & 0.37 & 0.12 & 0.09 & 0.05 \\ 0.31 & 0.35 & 0.18 & 0.11 & 0.05 \end{vmatrix}$$

Secondary evaluation is the evaluation of similar indicators. Formula (4) shows that:

$$B = A \cdot R = (0.3, 0.5, 0.2) \cdot \begin{vmatrix} 0.41 & 0.42 & 0.14 & 0.10 & 0.02 \\ 0.37 & 0.37 & 0.12 & 0.09 & 0.05 \\ 0.31 & 0.35 & 0.18 & 0.11 & 0.05 \end{vmatrix} = (0.37, 0.381, 0.138, 0.097, 0.041)$$

According to the principle of maximum membership degree mentioned above, due to  $0.381 \in \max(0.370, 0.381, 0.138, 0.097, 0.041)$ , the safety management level of the mining enterprise belongs to Level II, that is, a company with good safety management.

A spider web model map is drawn based on the score, as shown in Figure 2.

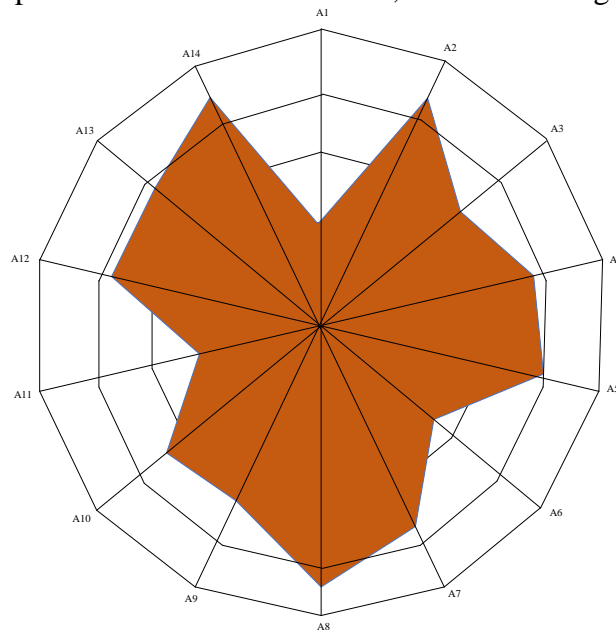


Fig. 2. The enterprise's cobweb model diagram of safety standardization system

It can be seen from Figure 2 that the safety production policy and objectives ( $A_1$ ), production

process system safety management ( $A_6$ ) and inspection ( $A_{11}$ ) have significantly lower scoring rates, indicating that these three aspects are the weak links of the enterprise's safety standardization system. It is also the object that requires companies to concentrate on making key improvements. These improvements will greatly improve the maturity level of the enterprise security standardization system [6]. Safety production laws and regulations and other requirements ( $A_2$ ), job site safety management ( $A_8$ ), performance measurement and evaluation ( $A_{14}$ ) have higher scoring rates, indicating that companies are doing well in these three areas and can continue to maintain existing practices. Other indicators are at an intermediate level, and companies can appropriately put a certain amount of energy into their attention and improvement [9]. Based on the daily inspection records of the mine and the internal evaluation report 5 months ago, it was found that there were a large number of non-conformities in the safety production policy and objectives ( $A_1$ ), production process system safety management ( $A_6$ ) and inspection ( $A_{11}$ ). In terms of safety production laws and regulations and other requirements ( $A_2$ ), job site safety management ( $A_8$ ), performance measurement and evaluation ( $A_{14}$ ), the three non-conformities are the least. It shows that the evaluation results of this model are more objective and accurate, and have a good agreement with the actual situation, which has certain application value [8].

## 5. Conclusion

Based on the investigation of mining enterprises, this paper analyzes the influencing factors of mine enterprise safety management level, and builds a mine enterprise safety management level evaluation model to help enterprises diagnose their safety management status and find the advantages and disadvantages of safety management. , propose the direction that enterprises need to improve next. The mining enterprise safety management level evaluation model provides enterprises with an effective method to evaluate their own safety management level. By assessing the current status of the company's own safety management level, it is the most important factor affecting the safety management level of the enterprise and the weakest link in the safety management.

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